
**ACIDIC PRECIPITATION IN ONTARIO STUDY:
TERRESTRIAL EFFECTS PROGRAMME
NORTHWESTERN REGION
1985 - 1986 ANNUAL REPORT**

Prepared for

The Acidic Precipitation in Ontario Study
The Ontario Ministry of the Environment

By

SENES Consultants Limited

In Association With

Lakehead University

Smith, Hoffman Associates Limited

Terra Geographical Studies Inc.

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March 1986

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Chapter 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Purposes and Outline

The purposes of this report are the following:

- a) to provide a description of the rationale for the biogeochemical study at Hawkeye Lake;
- b) to provide a chronology of the study to date;
- c) to provide a summary of the types of data collected to date;
- d) to provide a discussion of the accomplishments of the study to date in light of the original study goals;
- e) to recommend future developments and trends for the study to help in satisfying these goals.

To do this, this report is divided into six chapters. In Chapter 1, the introduction, the background of the project is discussed along with a brief description of the Hawkeye Lake site and the history of its development as a study site. In addition, a short summary is given of activities undertaken by the consultants as part of this contract but outside of the Hawkeye Lake site (1.11).

Specific study activities at Hawkeye Lake such as the Standing Crop Biomass Study and Stream Flowrate Monitoring are outlined in detail in Chapters 2 to 5. The sections divide the component activities into Once-only Studies (Chapter 2), Rainfall Event Monitoring (Chapter 3), Fixed Interval Monitoring (Chapter 4) and Continuous Monitoring (Chapter 5).

For each activity described in each chapter 27 in all, the activity sub-chapter is divided into the following headings: purpose, field activities, laboratory analyses, data storage and management, data analysis and comments. The purpose heading includes a short discussion of why the activity was thought to be meaningful and how it fits into the primary goals of the study. The headings dealing with field activities, lab analyses, data storage and

management, and data analysis include a description, chronology and status report as of March, 1986 (January 27, 1986 for laboratory analyses). The comments heading deals with problems encountered, accomplishments and future prospects.

General conclusions and recommendations are contained in Chapter 6.

1.2 Background to the Study

The Acidic Precipitation in Ontario Study (APIOS) was initiated in 1979 by the Ontario Ministry of the Environment (MOE) "... to protect Ontario's environment from the damaging effects of long range transport of air pollutants, their atmospheric transformation and their deposition." One of the six major tasks identified by APIOS was the study of terrestrial effects. In 1981 the Technical Subcommittee of the Terrestrial Effects Working Group (TEWG) was formed and it designated biogeochemical cycling as its first priority. It was proposed that several watersheds in parts of Ontario receiving different levels of acidic precipitation be studied in detail and then compared.

Two contrasting watersheds, subcatchments of Harp Lake and Plastic Lake, were selected in the Muskoka-Haliburton area near Dorset in 1981 to represent forested watersheds receiving relatively high acidic precipitation loading (Southern Biogeochemical Study Site). Monitoring at these two watersheds began in 1982. Two northern Ontario sites were approved in September 1982. A site near Sudbury, High Falls catchment area, was selected as a site with moderate loading and monitoring began in 1983 (Northeastern Biogeochemical Study Site). A Hawkeye Lake subcatchment near Thunder Bay was selected to represent a low loading or control situation and monitoring began in 1983 (Northwestern Biogeochemical Study Site).

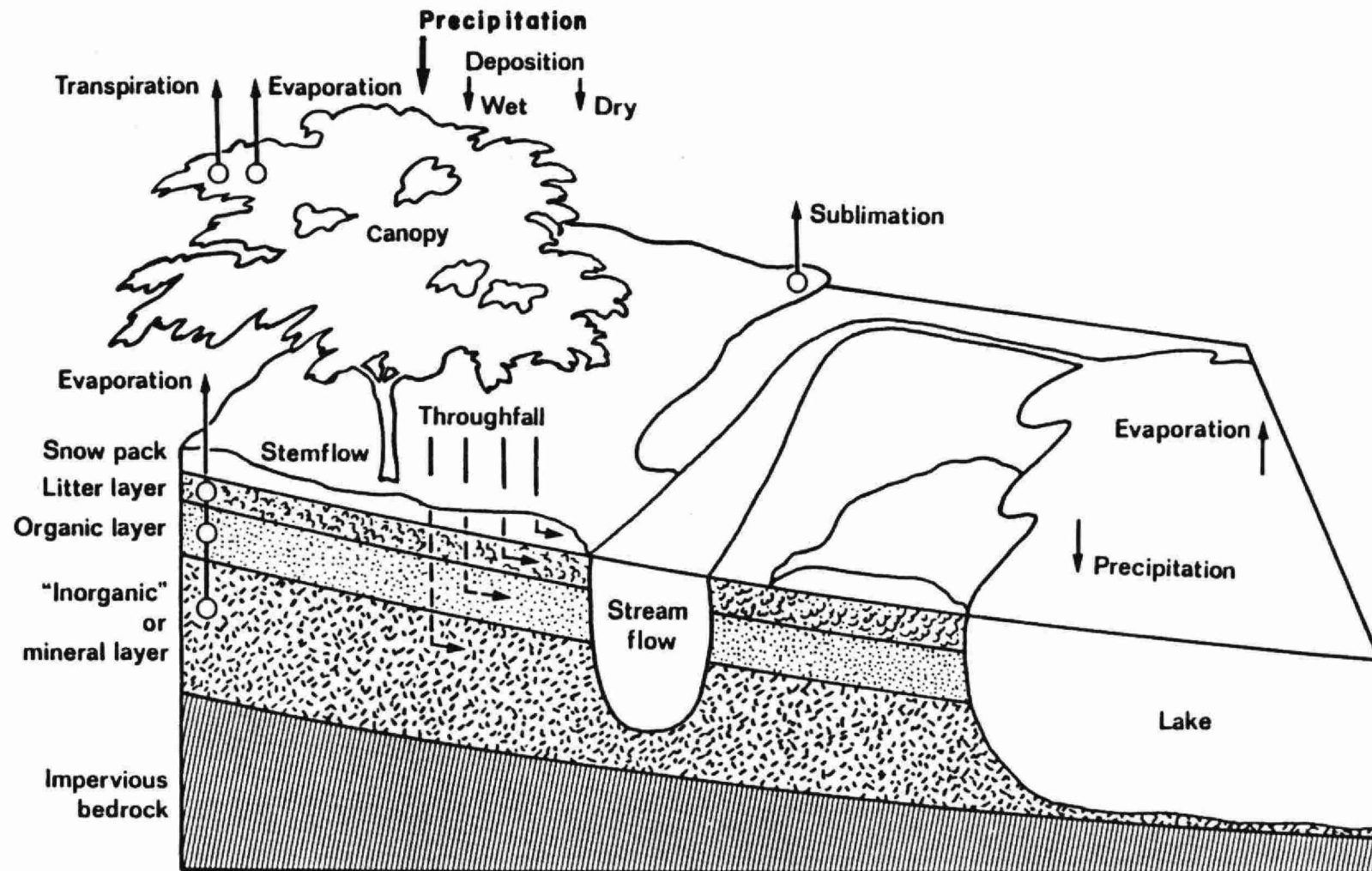
A basic premise for setting up the biogeochemical cycle studies was that knowledge gained about nutrient fluxes within a watershed could lead to a better understanding of watershed processes which could then be modelled. The

models could then be used to help predict the possible effects of acidic deposition on the watersheds and associated waterbodies. Figures 1 and 2 show in a very simplified form some of the complex interactions which need to be understood and quantified within a watershed to attempt to model the fate of acidic precipitation in the watershed. The biogeochemical cycling field studies by themselves cannot produce evidence that will show conclusively what the effects of acidic deposition on the watersheds are and were not designed to do this.

An experimental unit is defined as consisting of a forest canopy, biologically active soil layer underlain by impervious rock, surface stream flow and a lake (see Figure 1). On this watershed, cations, anions and trace elements are received from the atmosphere and geologic weathering, and become a part of the nutrient pool in the soil. These, in turn, are taken up by living organisms and are subsequently returned to the soil through the process of decomposition. Nutrients may leave via streamflow and thus make their way into the lake. Nutrients are measured along the various pathways of the hydrologic cycle - the main vehicle governing nutrient movement - providing insight into the nutrient distribution, cycling and budget of the study watershed.

A great deal of detailed information is needed from a watershed to determine the nutrient fluxes. However even the smallest of watersheds with a perennial, or nearly perennial stream is far too large to study in total. It is therefore necessary to sample within the watershed. There are two possible basic sampling strategies for variables relating to the canopy. An areal strategy is to select plots within the watersheds and measure all the canopy-related fluxes within these plots. The plot results can then be simply related to the watershed as a whole, especially if the plots were selected in a statistically valid way so as to be representative of the canopy of the entire watershed. Another strategy is to select specimens of the main tree species and measure the fluxes for these trees and the areas immediately around them. This is a non-areal or plotless strategy because data are not gathered for a defined area. The data for the trees can be related to the

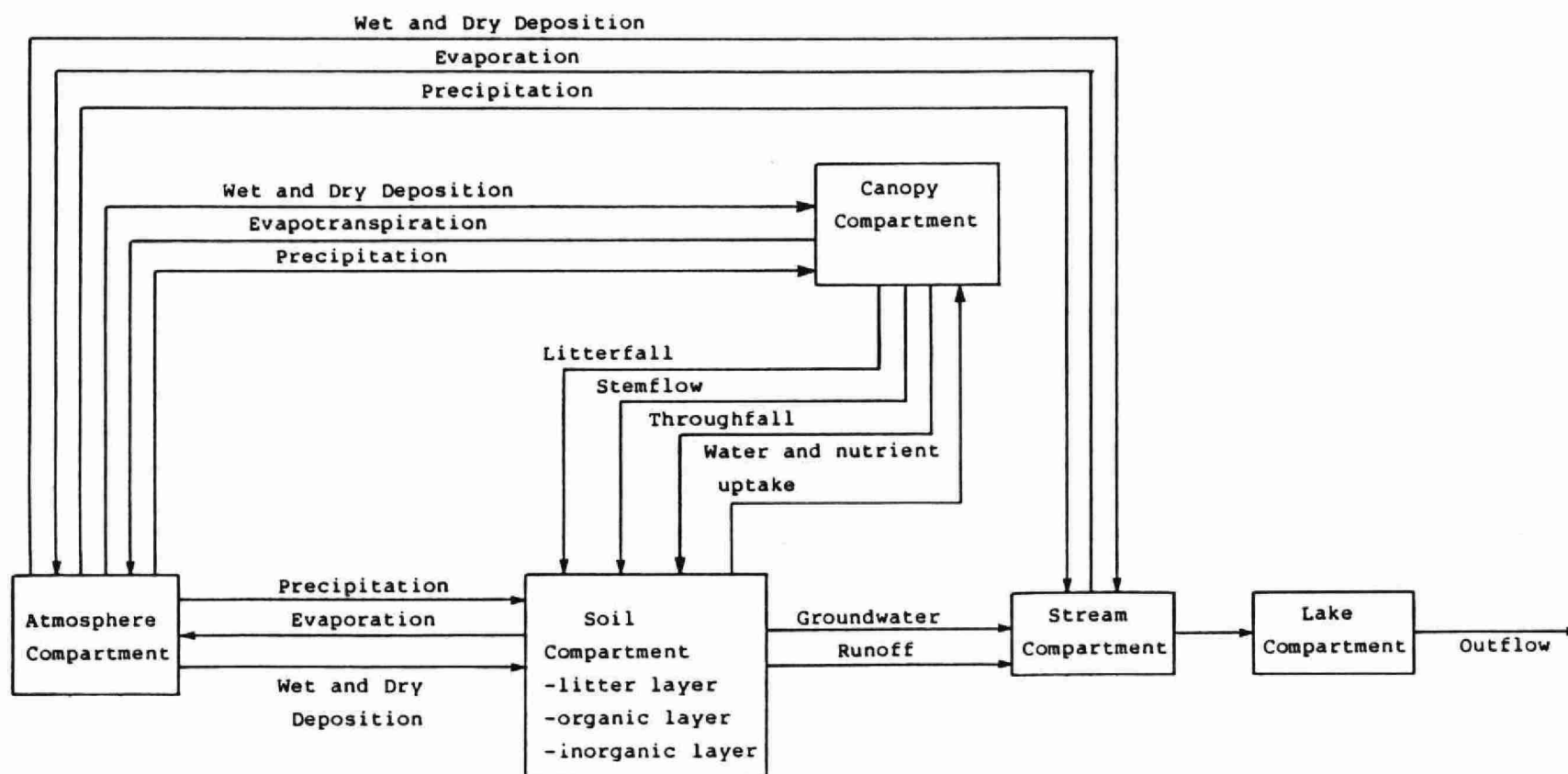
FIGURE 1
THE FORESTED WATERSHED



SOURCE: ADAPTED FROM EPRI, 1983

FIGURE 2

ACID DEPOSITION COMPONENT MODELS



watershed as a whole by extrapolation back from information on tree stocking within the watershed. The specimen trees are chosen from a group of trees of the same species growing close together. For this reason this strategy is termed the grove strategy.

Both strategies have advantages and disadvantages. The areal strategy may be of more evident application but it is considerably more sampling intensive than the grove strategy. The choice of truly representative plots may also be difficult. The grove strategy gives useful data on single species that may be difficult to relate back to the kind of mixed forests often found in the Shield forests.

Originally a grove strategy was used exclusively at all sites, however, in 1985 areal sampling for some canopy related items began at Harp Lake and Plastic Lake. The implications of this for Hawkeye Lake are discussed in Section 6.

The general pattern of data collection at Hawkeye Lake follows the fluxes identified in Figures 1 and 2. Inputs of rain and snow are followed as they undergo modification through the forest canopy, through the forest floor and underlying soil, and finally as they emerge as streamflow discharged from the watershed.

Analyzers in a trailer at the main instrument site continuously measure atmospheric concentrations of sulphur dioxide, ozone, and nitrogen oxides. All of these pollutants may be transported long distances and play a role in acid rain effects. To help indicate the source of these contaminants, wind sensors have been installed on a nearby tower. Incident precipitation quantity and chemistry are monitored with sampling equipment on a platform near the instrument trailer. A sheltered weir monitors water quantity and quality in the stream draining the study area.

Changes in rain chemistry below the forest canopy are studied with a network

of special rainfall collectors in groves of trembling aspen, white birch, balsam fir, white pine, black spruce and jack pine trees. Rainwater flowing down tree trunks (stemflow) and through tree crowns (throughfall) is chemically analysed after each period of rain. Groundwater at three levels below the soil surface in the groves is sampled and analysed. Leaves, twigs and other debris which fall to the ground are weighed and analysed, and their decomposition rates are measured. Other studies determine the total quantity and chemical makeup of living matter (biomass) in the watershed.

1.3 Project Management

The overall direction of the biogeochemical studies was initially provided by the Terrestrial Effects Working Group (TEWG) which meets regularly, usually in Toronto. The direction of the biogeochemical studies was transferred to the Biogeochemical Working Group in July, 1985. The actual running of the individual watershed programs is carried out by outside consultants on a contract basis and under supervision of MOE staff. For Hawkeye Lake, the original 3-year contract was awarded to the Lakehead University Centre for Regional Development which ran the project from April, 1982 to March, 1985. In April, 1985 the project was re-tendered and the new contract awarded to SENES Consultants Ltd. in association with Smith, Hoffman Associates Ltd. and TERRA Geographical Studies Inc. SENES elected to keep the original field team, on a sub-contract basis, to maintain the continuity of data collection. The current key personnel and their roles are shown on Table 1.

The biogeochemical study at Hawkeye Lake is only one component, albeit the largest one, in the contracts awarded both to Lakehead University and SENES. Other studies, which remained under the direction of the Terrestrial Effects Working Group are briefly described in 1.11.

Table 1

CURRENT KEY STAFF

SENEC Consultants Limited (Prime Contractor)

Dr. Eugene Koczur	Project Director
Ms. Valerie Cassaday	Project Manager
Mr. Don Beals	Data Management Specialist

Lakehead University (Sub-contractor)

Mr. Reino Viitala	Full-time Soil Specialist
Ms. Irene Westelaken	Full-time Biologist
Ms. Judy Commisso	Laboratory Technician
Dr. Paul Barclay	Technical Advisor

Smith, Hoffman Associates Ltd. (Sub-contractor)

Mr. Mike Hoffman	Soil Specialist
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TERRA Geographical Studies Inc. (Sub-contractor)

Dr. Eric Muller	Biologist
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(Note: all staff part-time unless otherwise noted)

1.4 Site Selection

It was originally hoped that the biogeochemical study sites selected in different parts of Ontario would be as similar as possible except for acid loading. The following criteria were considered in selecting the sites:

1. Each study area was to be readily defined within the drainage basin of a headwater stream. The presence of ponds or swamp conditions along the course of the stream monitored could create problems in data interpretation. The recommended size for a study watershed was between 25 and 150 hectares.
2. The two northern Ontario sites were to be as similar as possible in vegetation composition, particularly with respect to tree species.
3. Soil in each area was to be "sensitive" to acidification (sandy, low cation exchange capacity).
4. Study sites were to be subjected to different acidic deposition loading.
5. Study sites should, if possible, have similar histories with respect to fire and harvesting.
6. All sites were to be accessible year round, preferably by road, and not influenced by local contaminant sources such as well-travelled unpaved roads. Sites were to be available on long-term tenure and free of potential vandalism. Access to electric power and a telephone line was desirable.

(APIUS Procedures Manual 1983).

It was soon apparent that not all criteria could be met at each site. As mentioned previously, the southern Ontario watersheds were selected first. They were chosen in part because they were already being intensively investigated by the Ministry's Water Resources Branch. Problems arose when trying to find appropriate northern Ontario watersheds. A subcatchment of Hawkeye Lake was selected in July, 1982 as being the best site for the Northwestern Region. In September, 1982, key members of the Technical Subcommittee and the Chairman of the TEWG met to discuss the problem. The mixed forest sites chosen near Thunder Bay and Sudbury were dissimilar in

terms of soils and to some extent vegetation. It was finally decided to adopt the two watersheds in spite of their differences, recognizing that some data would not be comparable. It was also decided to carry out a secondary study on a jack pine grove outside each watershed. Recognition was made of the fact that because of different climate, acid loadings, tree species composition and soils, the four watersheds would generate modelling data which would be different for each site. The original information on the four watersheds is shown on Table 2 and their locations on Figure 3.

Table 2

ORIGINAL COMPARISON OF THE FOUR ONTARIO BIOGEOCHEMICAL STUDY WATERSHEDS

<u>Features</u>	<u>Harp(S)</u>	<u>Plastic(S)</u>	<u>High Falls (NE)</u>	<u>Hawkeye (NW)</u>
Area (ha)	120	25	110	85
Wetlands and ponds (%)	6	1	1	8
Exposed Bedrock (%)	1	1	2-3	1
Unforested upland (%)	2	nil	nil	nil
Soil depth	up to 30 m	0.5 m	0-5 m(?)	up to 25 m
Soil texture ^a	sandy loam to loamy sand	sandy loam	silty loam to silty clay-loam	silty loam to loamy
Soil pH, mineral horizon	5	5	5	5
Soil CEC (estimate for B horizon) (meq/100 gm)	2	2	4	3
Tree species, in order of decreasing basal area	maple, aspen ^b , yellow birch, beech	white pine, aspen ^b , hemlock, maple, oak	aspen ^b , birch, spruce, red maple, white pine, balsam fir	balsam fir, aspen ^b , birch, spruce, cedar, white pine
Annual precipitation (mm) (years of data)	970 (20y)	1100 (7y)	840 (70y)	710 (40y)
Mean annual temperature (°C)	5.2	4.4	4.1	2.3
Total sulphate loading (kg/ha/y)	40	40	25	10

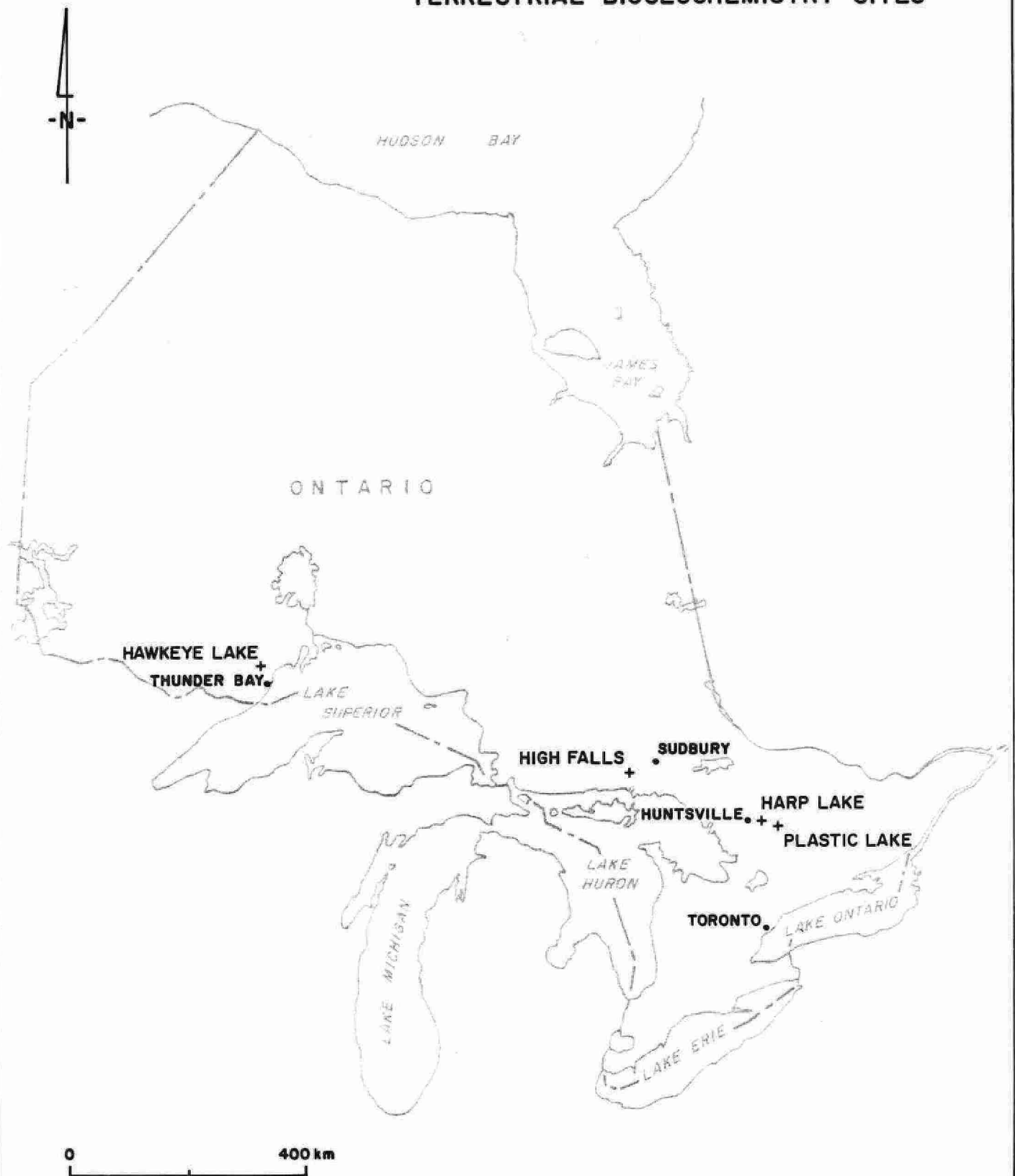
^a Canadian Soil Classification

^b Mixture of trembling aspen and large tooth aspen at Harp Lake and High Falls, trembling aspen only at Hawkeye Lake.

From: Overview Biogeochemical Studies, Acidic Precipitation in Ontario Study (1983).

FIGURE 3

ONTARIO MINISTRY OF THE ENVIRONMENT
TERRESTRIAL BIOGEOCHEMISTRY SITES



1.5 Basic Site Description

The location of the Hawkeye Lake Biogeochemical Site is shown on Figure 4. A report on site characteristics and forest history is currently in progress and will be completed in March, 1986. The following description is based on the description in the Hawkeye Lake Biogeochemical Study Site Preliminary Report (1984).

The Hawkeye Lake watershed lies within the Humid Continental, Cool Summer climatic zone. Climatic data from 1951 to 1980 are available for two of the nearest meteorological stations, Dog Lake Dam and Kakabeka Falls, 13 km WNW and 31 km SSW of Hawkeye Lake respectively. At Dog Lake Dam, values are available only for precipitation. The data from the Kakabeka Falls station are more complete but provide only an estimate of the conditions at the Hawkeye Lake watershed, since Kakabeka Falls is approximately 150 m lower in elevation and is farther south of the watershed. In general, the summers are often cool, but at times temperatures can reach 38°C. Winters are cold, with temperatures of -40°C reached several times in most winters.

The Canadian Precambrian Shield is the major geological unit in this region. The Hawkeye Lake watershed lies within the Superior Province of the Shield. In this area, the bedrock is granite and granitic gneiss, composed primarily of quartz, feldspar, and mica. Due to its low to insignificant buffering capacity, the bedrock has been given a rating of high sensitivity to acid precipitation on a 1981 map prepared by the Geological Survey of Canada. The Dog Lake Moraine is the dominant landform on the southwestern portion of the watershed. This end moraine was deposited along the margin of a glacier and marks the approximate southern limit of readvance of the Hudson Bay ice mass during the Dog Lake phase. The rest of the watershed is dominated by ground moraine. The topography in this area is moderate in relief and generally consists of a broad rolling surface.

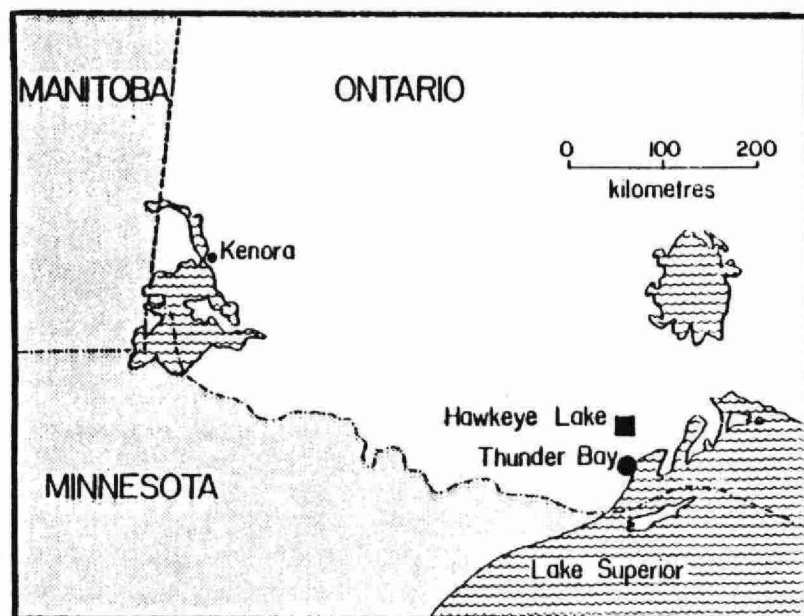
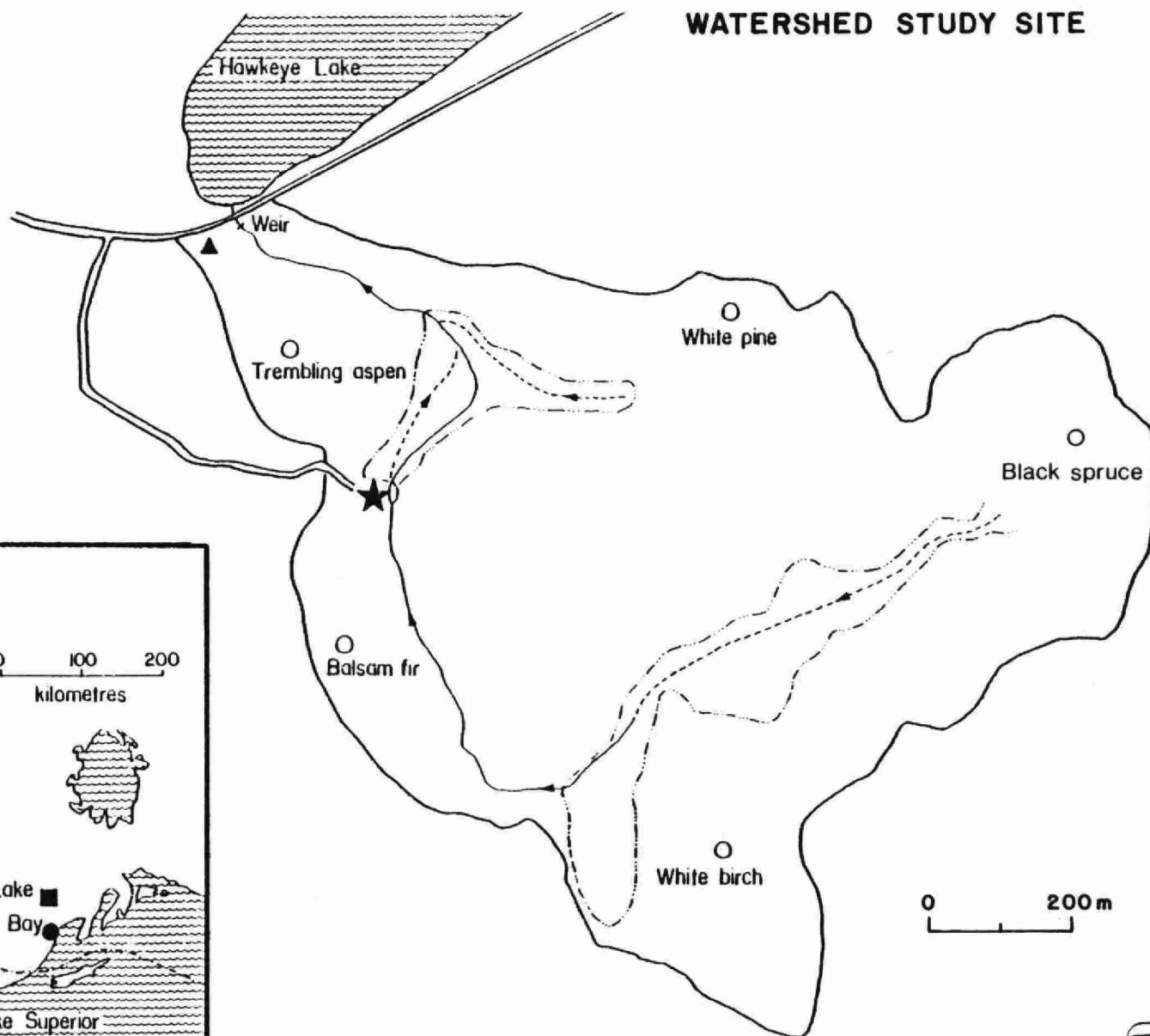
FIGURE 4

HAWKEYE LAKE WATERSHED STUDY SITE



LEGEND:

- Watershed boundary
- - - Swamp
- Stream
- Precipitation study groves
- ★ Main instrument site
(air quality, meteorology)
- ▲ Soil column experiment



Drainage of the watershed is from east to west and south to north. The main stream runs through the western side of the watershed and empties into the southwestern corner of Hawkeye Lake.

The soils are mostly developed from glacially deposited overburden which is primarily made up of gravel, boulders, and sand. The soil itself is mostly composed of sand, with some silt and a small component of clay. Soils on the watershed are not mature and tend to be brunisols, some of which are slightly leached tending towards podzolization. In the lowland areas, the organic soils can be in excess of 2 m deep.

The vegetation on the watershed falls in the Superior Forest Section of the Boreal Forest Region. The boreal forest is a dynamic successional forest resulting from fires, which occur every 70 to 100 years. More recently successional change is associated with logging. Fires and logging produce an enormous mosaic of different-aged stands with different species compositions. Generally, though, black spruce (Picea mariana) is the dominant tree on the thin acid soils of upland areas and also on organic soils of poorly-drained lowlands. Jack pine (Pinus banksiana) is widespread on well-drained gravel and sand acid soils. On mesic sites of undifferentiated glacial till, which is typical of the Hawkeye watershed, white spruce (Picea glauca), balsam fir (Abies balsamea), white birch (Betula papyrifera) and trembling aspen (Populus tremuloides) are common tree species. White pine (Pinus strobus) and larch (Larix laricina) are less common species. A number of shrubs, herbs, bryophytes, and lichens are common constituents of these forests.

1.6 Site Preparation

Site preparation was a major activity in the Hawkeye Lake watershed from 1982 to 1984. It is ongoing today for a few specific items.

Site preparation involved the following main activities:

- a) installation of support facilities such as the access road, the on-site trailers, electricity, telephone and trails;
- b) installation of the main instrument platform and meteorological tower;
- c) selection and establishment of sampling stations in groves of balsam fir, white pine, white birch, trembling aspen, black spruce and jack pine;
- d) construction of a weir and stream gauge shed.

A chronology of site preparation activities is shown on Table 3. The actual distribution of the facilities is shown on Figures 4 to 12 and Photographs 1 to 18. A detailed photographic progress record was kept as various facilities were constructed.

Site preparation was very carefully carried out so as to minimize impact on the watershed. Elevated pathways and work tables have been set up in the sampling groves to reduce possible trampling and soil compaction during sampling. Signs and a demonstration sampling grove have been set up outside the watershed so that visitors and the public can see what work is being performed on site without causing damage. No motorized vehicles are used in the study area.



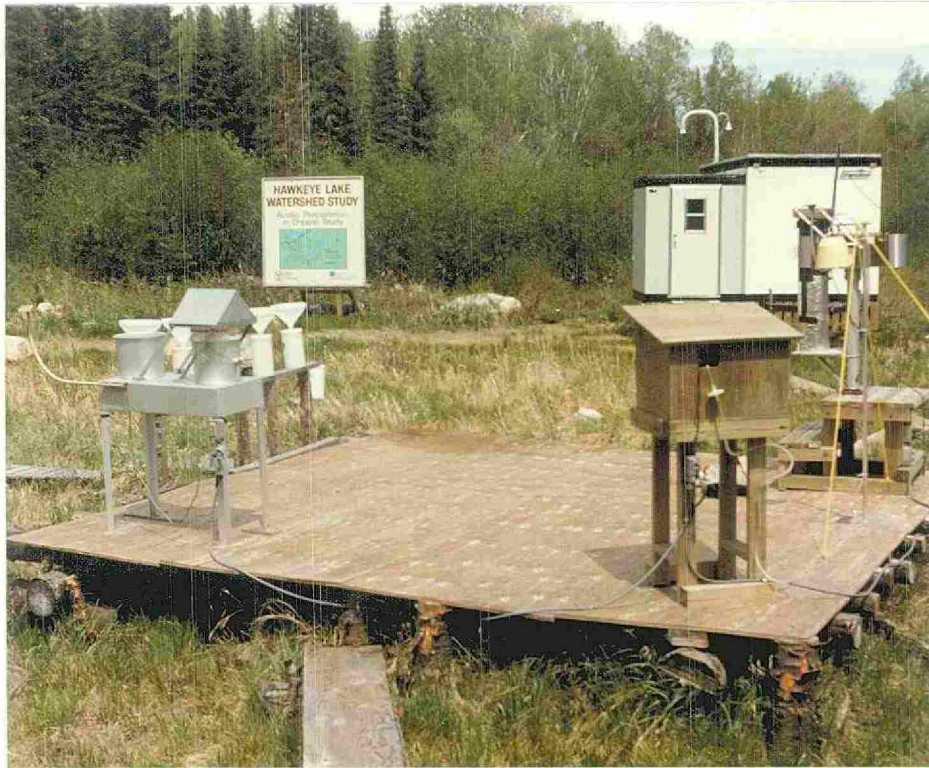
PHOTOGRAPH 1: View of the Clearing

NOTES: This view was taken from the top of the meteorological tower looking south in the summer of 1984. The instrument platform, instrument trailer and main visitor sign are visible. The utility trailer is located to the right of the sign but is not visible on the photograph.



PHOTOGRAPH 2: The Equipment Trailer

NOTES: This view was taken looking northeast in December, 1984. The intake for the air quality monitors is visible above the trailer. The meteorological tower is also visible. The funnel incident collectors are on the right, on the instrument platform. A rain gauge is visible behind the walkway.



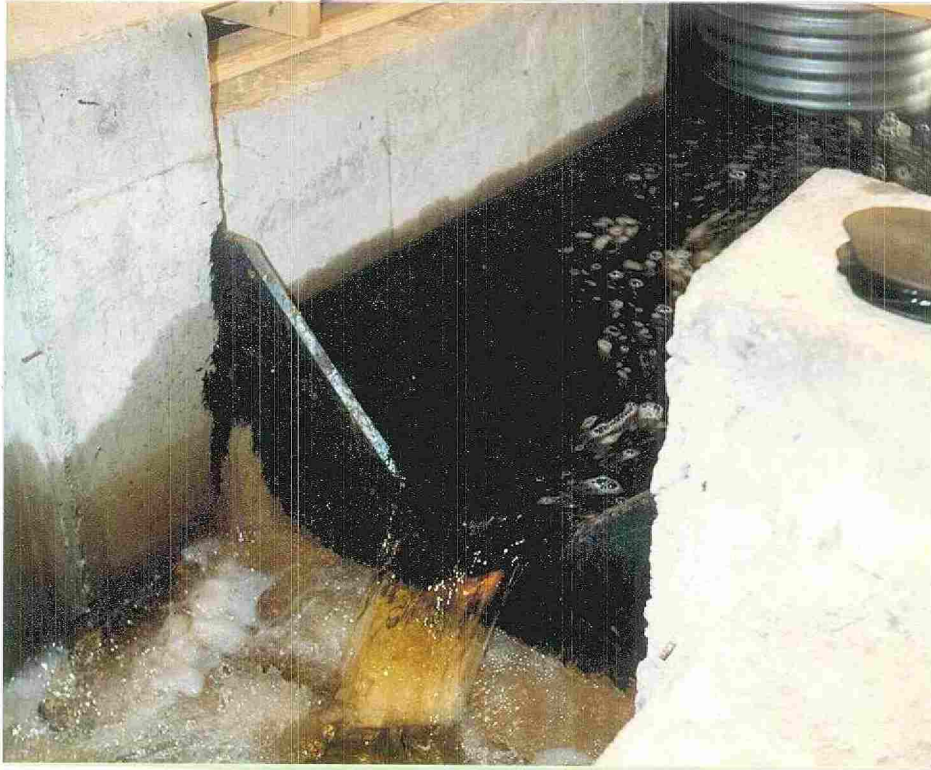
PHOTOGRAPH 3: The Instrument Platform

NOTES: This view was taken looking north in June 1985. On the left part of the platform are the five funnel incident rainfall collectors and the Aerochem Metric precipitation collector. On the right are the low volume air sampler, in the foreground, and the Sangamo precipitation collector, in the background.



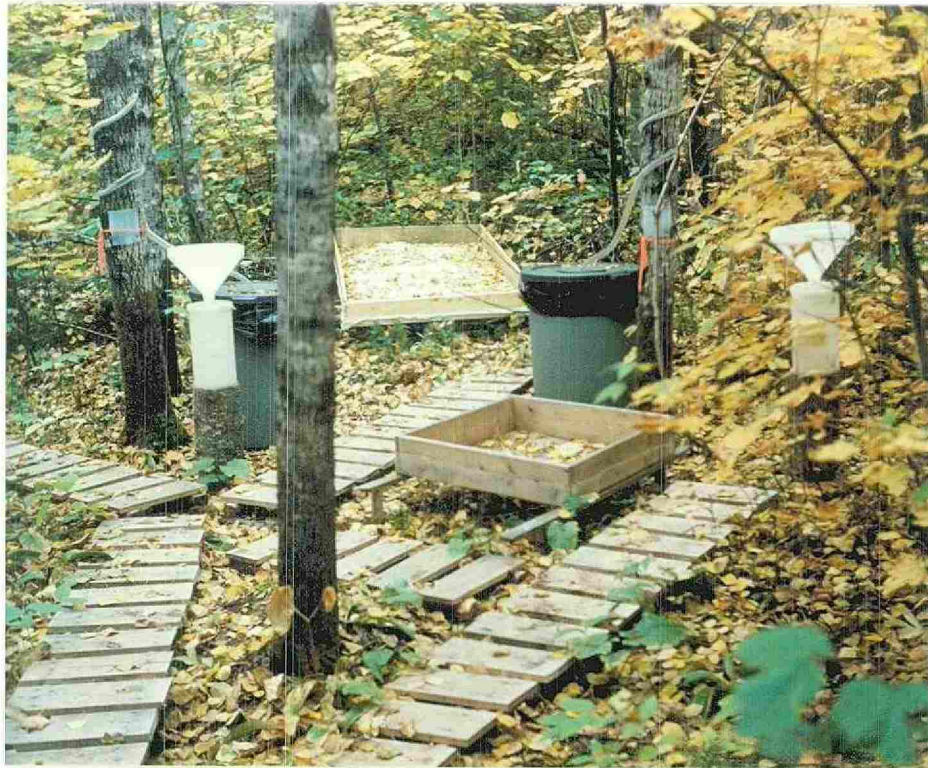
PHOTOGRAPH 4: Winter Monitoring in the Clearing

NOTES: This view was taken looking north in December, 1984. One of the three garbage can snow collectors is visible in the left foreground. Behind it are the two Nipher snow gauges. The Stevenson screen is visible between the Nipher gauges.



PHOTOGRAPH 5: Spring Runoff at the Weir

NOTES: This photograph was taken in the spring of 1984 and shows the steel weir plate firmly fixed in concrete within the heated weir enclosure. The sheath of the stilling well is visible in the upper right corner.



PHOTOGRAPH 6: The Trembling Aspen Grove

NOTES: This photograph was taken in September, 1984.



PHOTOGRAPH 7: The White Pine Grove

NOTES: This photograph was taken in September, 1984.



PHOTOGRAPH 8: The New White Birch Grove

NOTES: This photograph was taken in September, 1984.



PHOTOGRAPH 9: The Balsam Fir Grove

NOTES: This photograph was taken in October, 1985. A shrub throughfall collector is visible in the foreground.



PHOTOGRAPH 10: The Balsam Fir Grove in Winter

NOTES: This photograph was taken in the winter of 1984-1985. A garbage can snowfall collector is visible.



PHOTOGRAPH 11: The Black Spruce Grove

NOTES: This photograph was taken in October, 1985. The moss covered forest floor is evident.



PHOTOGRAPH 12: The Jack Pine Grove

NOTES: This photograph was taken in October 1985.



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PHOTOGRAPH 13: Tension Lysimeter Pit

NOTES: This photograph was taken in November, 1983 at the white pine grove during the installation of the lysimeters. The pit was subsequently filled in.



PHOTOGRAPH 14: Sampling for Tension Lysimeter Leachate

NOTES: This photograph was taken in July, 1984. The vacuum bottle and sample bottles for the LFH, B and C horizons are visible.



PHOTOGRAPH 15: Zero Tension Lysimeter

NOTES: This photograph was taken in October, 1985 at the white birch grove and shows the location of the lysimeters in the soil horizon.



PHOTOGRAPH 16: Zero Tension Lysimeter Pit

NOTES: This photograph was taken in October, 1985 at the white birch grove and shows the pit ready for leachate collection.



PHOTOGRAPH 17: Litter Decomposition Plot

NOTES: This photograph was taken in October, 1985 at the black spruce grove. It shows the sample bags laid out. Subsequently the bags were placed below the moss layer.



PHOTOGRAPH 18: Water-Table Monitor

NOTES: This photograph was taken in September 1984 and shows the Stevens A-35 water level recorder at map coordinates H7.

FIGURE 5
DEPOSITION MONITORING
INSTRUMENT PLATFORM

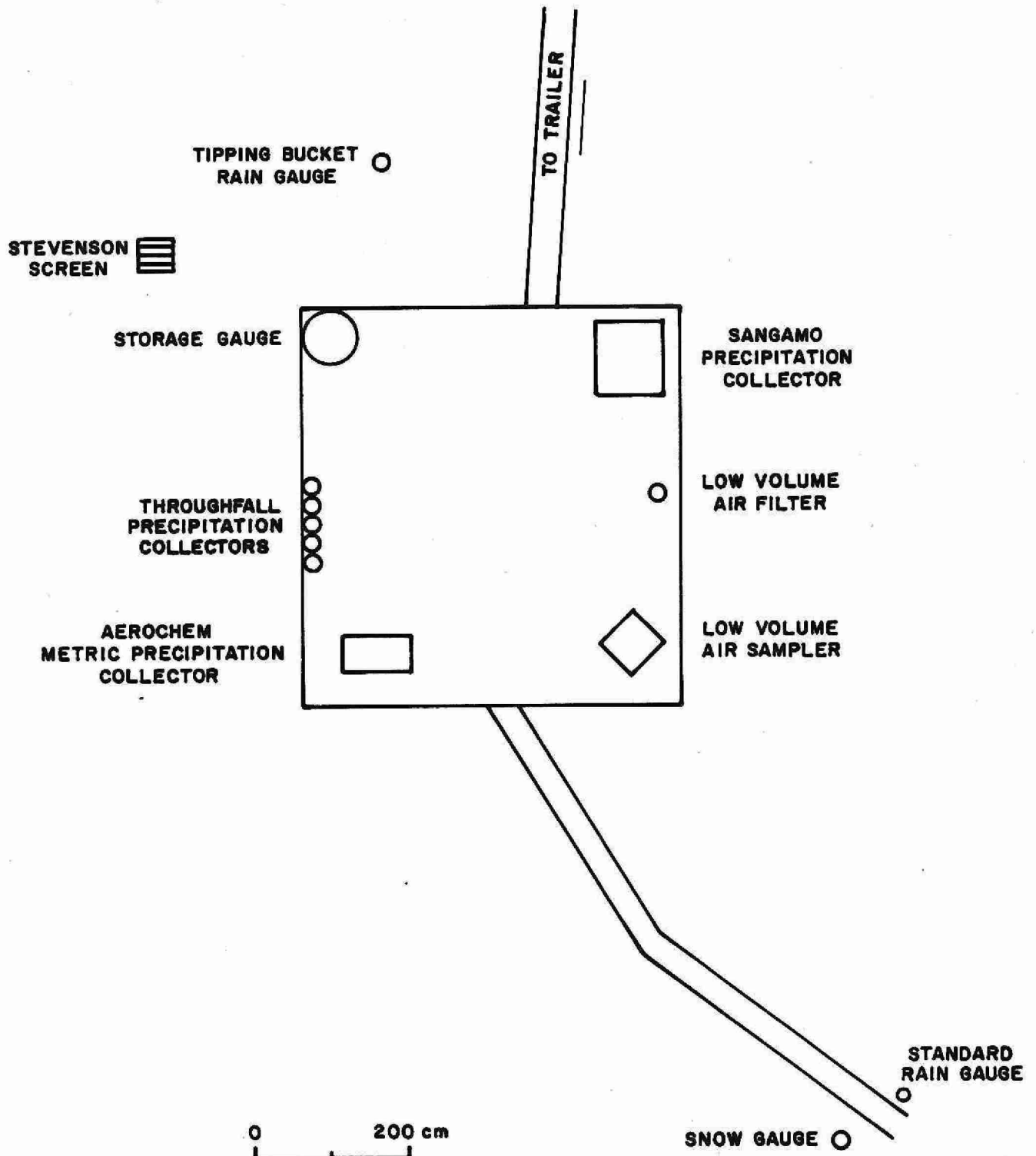


FIGURE 6
BALSAM FIR
PRECIPITATION STUDY GROVE

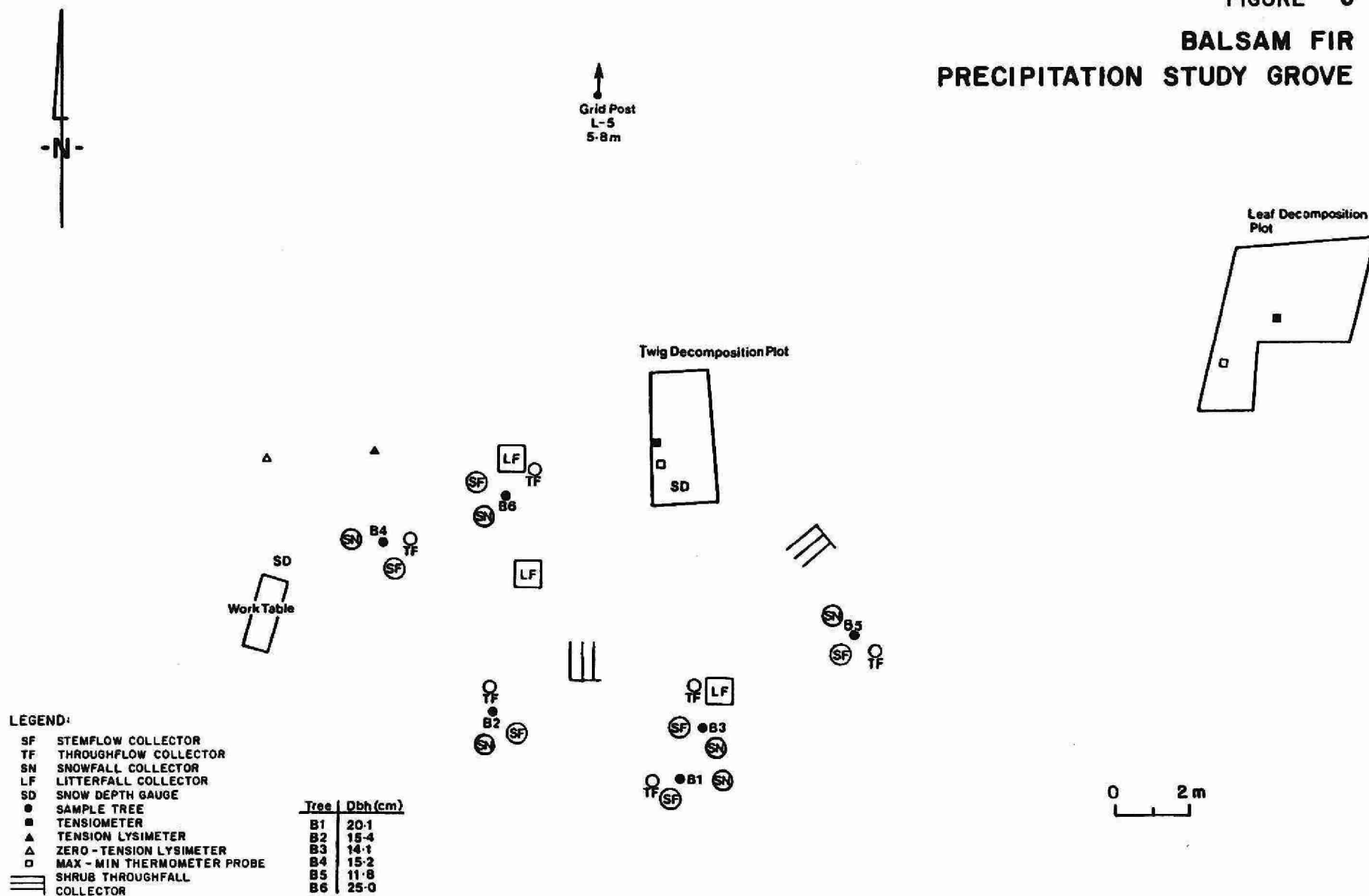
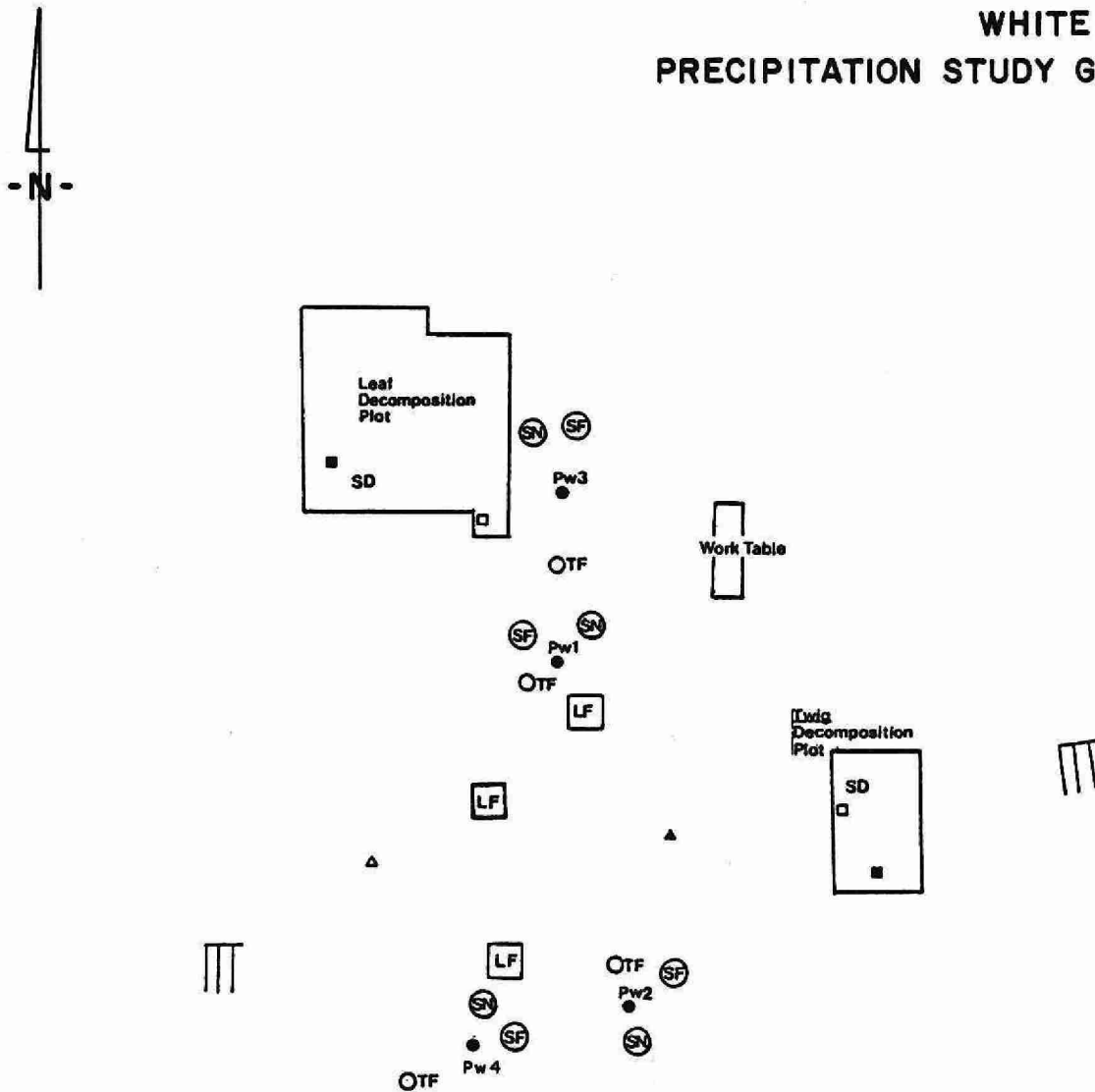


FIGURE 7
WHITE PINE
PRECIPITATION STUDY GROVE



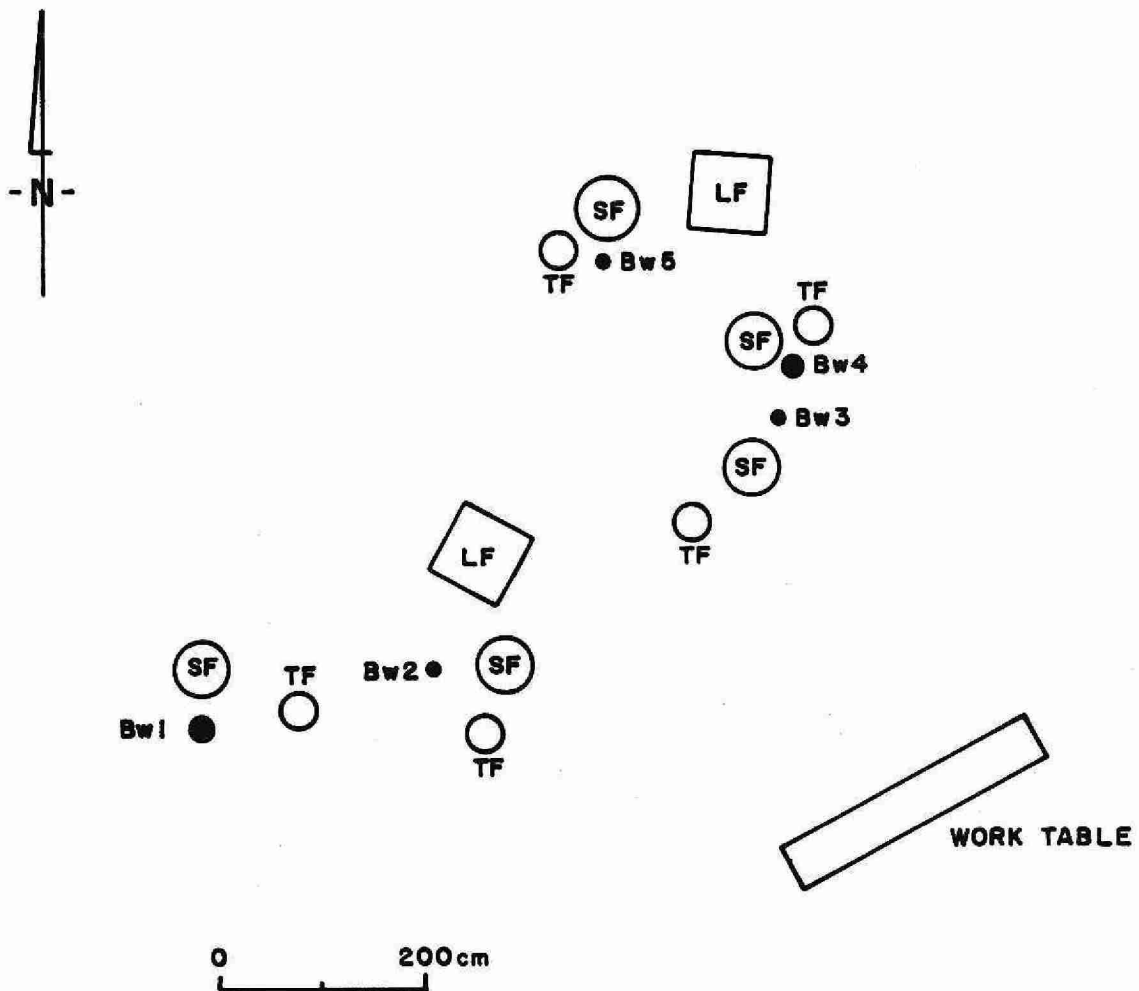
LEGEND:

- SF STEMFLOW COLLECTOR
- TF THROUGHFLOW COLLECTOR
- SN SNOWFALL COLLECTOR
- LF LITTERFALL COLLECTOR
- SD SNOW DEPTH GAUGE
- SAMPLE TREE
- TENSIMETER
- ▲ TENSION LYSIMETER
- △ ZERO-TENSION LYSIMETER
- MAX-MIN THERMOMETER PROBE
- ≡ SHRUB THROUGHFALL COLLECTOR

Tree	Dbh(cm)
Pw1	14.7
Pw2	23.7
Pw3	39.2
Pw4	38.0

0 2 m

FIGURE 8
ORIGINAL WHITE BIRCH
PRECIPITATION STUDY GROVE



LEGEND:

SF STEMFLOW COLLECTOR
TF THROUGHFALL COLLECTOR
LF LITTERFALL COLLECTOR
● SAMPLE TREE

TREE	DBH (cm)
Bw1	30.2
Bw2	11.6
Bw3	14.1
Bw4	20.1
Bw5	11

FIGURE 9
TREMBLING ASPEN
PRECIPITATION STUDY GROVE

LEGEND:

- SF STEMFLOW COLLECTOR
- TF THROUGHFLOW COLLECTOR
- SN SNOWFALL COLLECTOR
- LF LITTERFALL COLLECTOR
- SD SNOW DEPTH GAUGE
- SAMPLE TREE
- TENSIMETER
- ▲ TENSION LYSIMETER
- △ ZERO-TENSION LYSIMETER
- MAX-MIN THERMOMETER PROBE

Tree	Dbh (cm)
Po1	22.8
Po2	15.8
Po3	19.2
Po4	17.6
Po5	14.0

0 2m

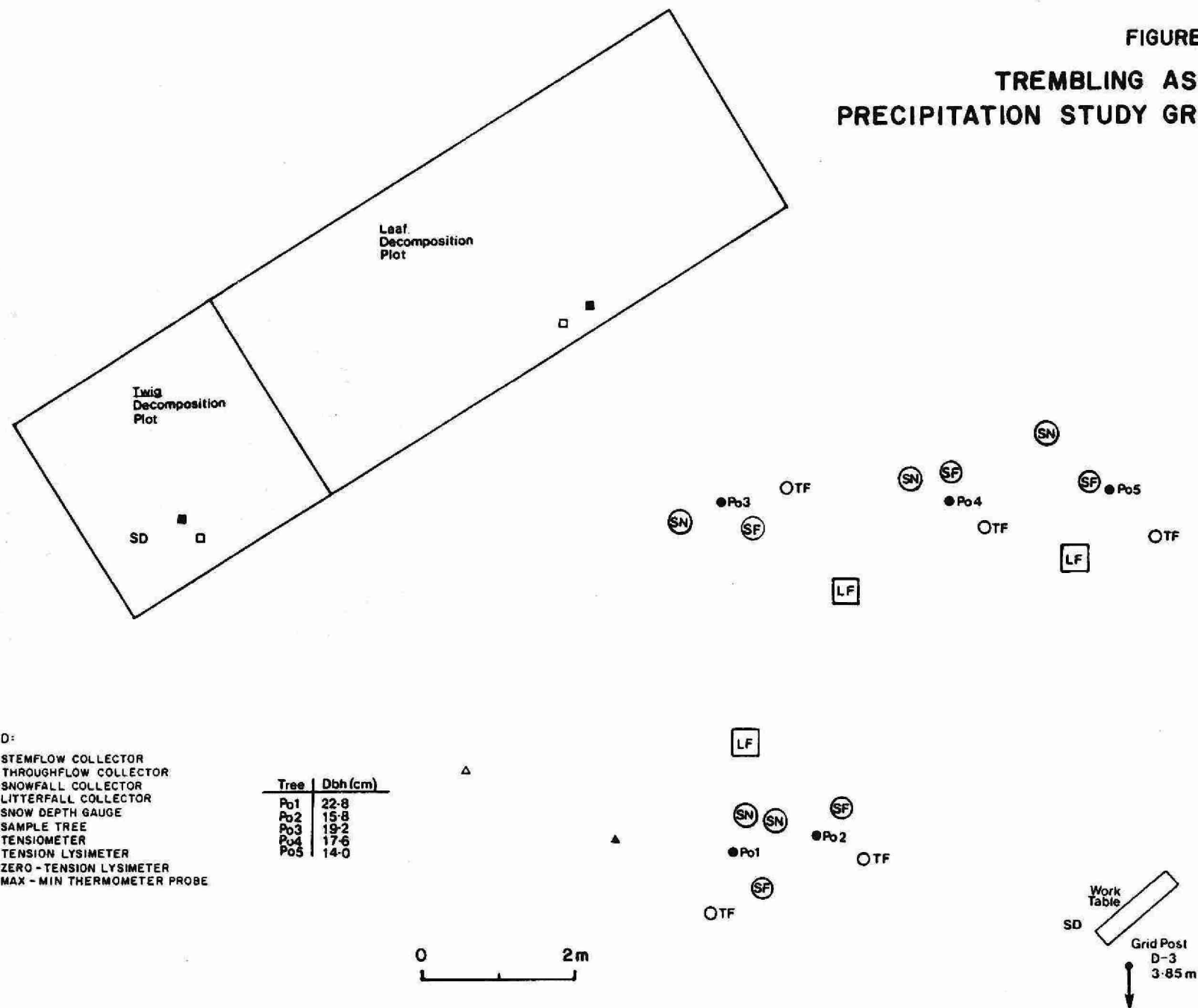


FIGURE 10
NEW WHITE BIRCH
PRECIPITATION STUDY GROVE

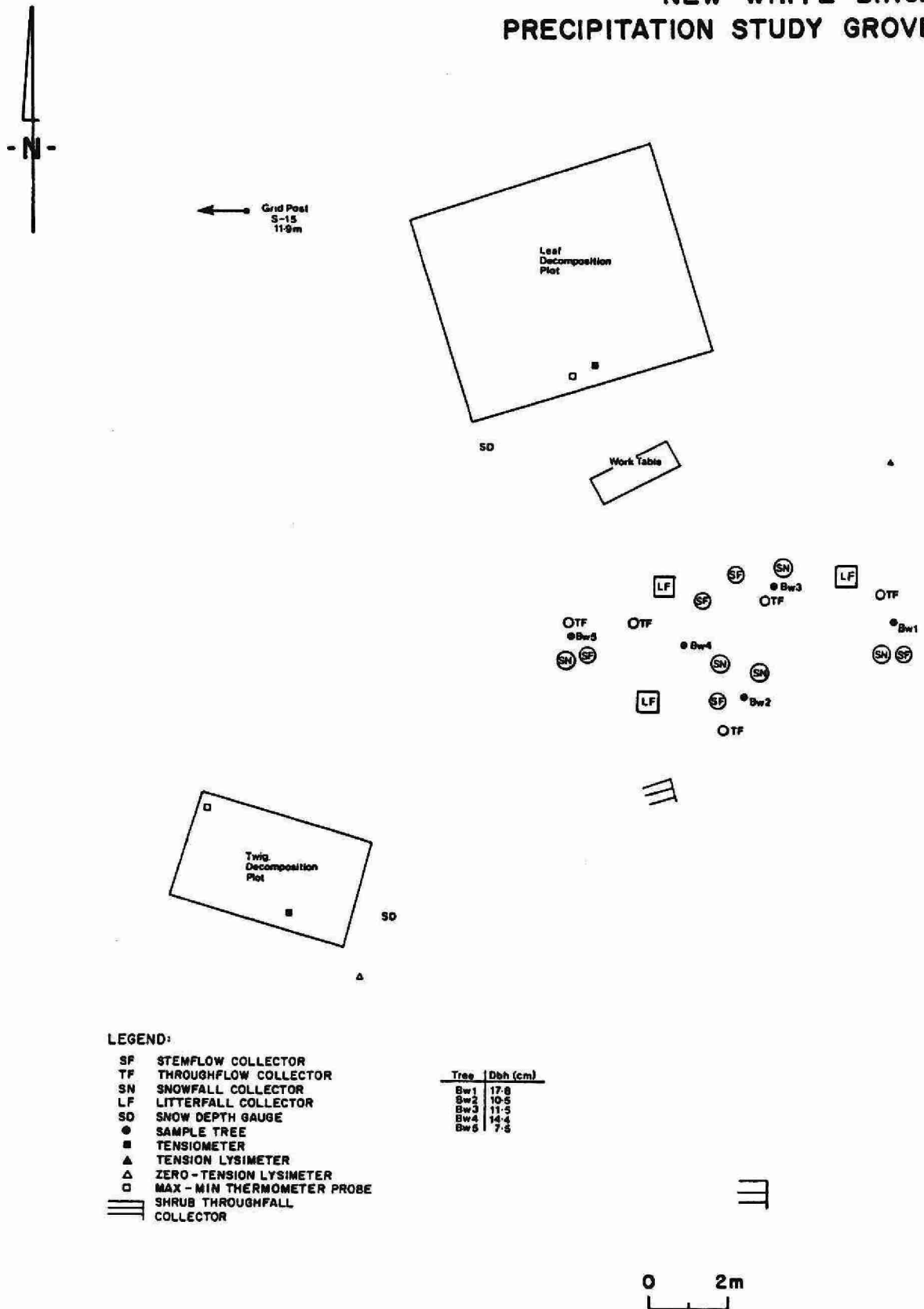


FIGURE II JACK PINE STUDY PRECIPITATION GROVE

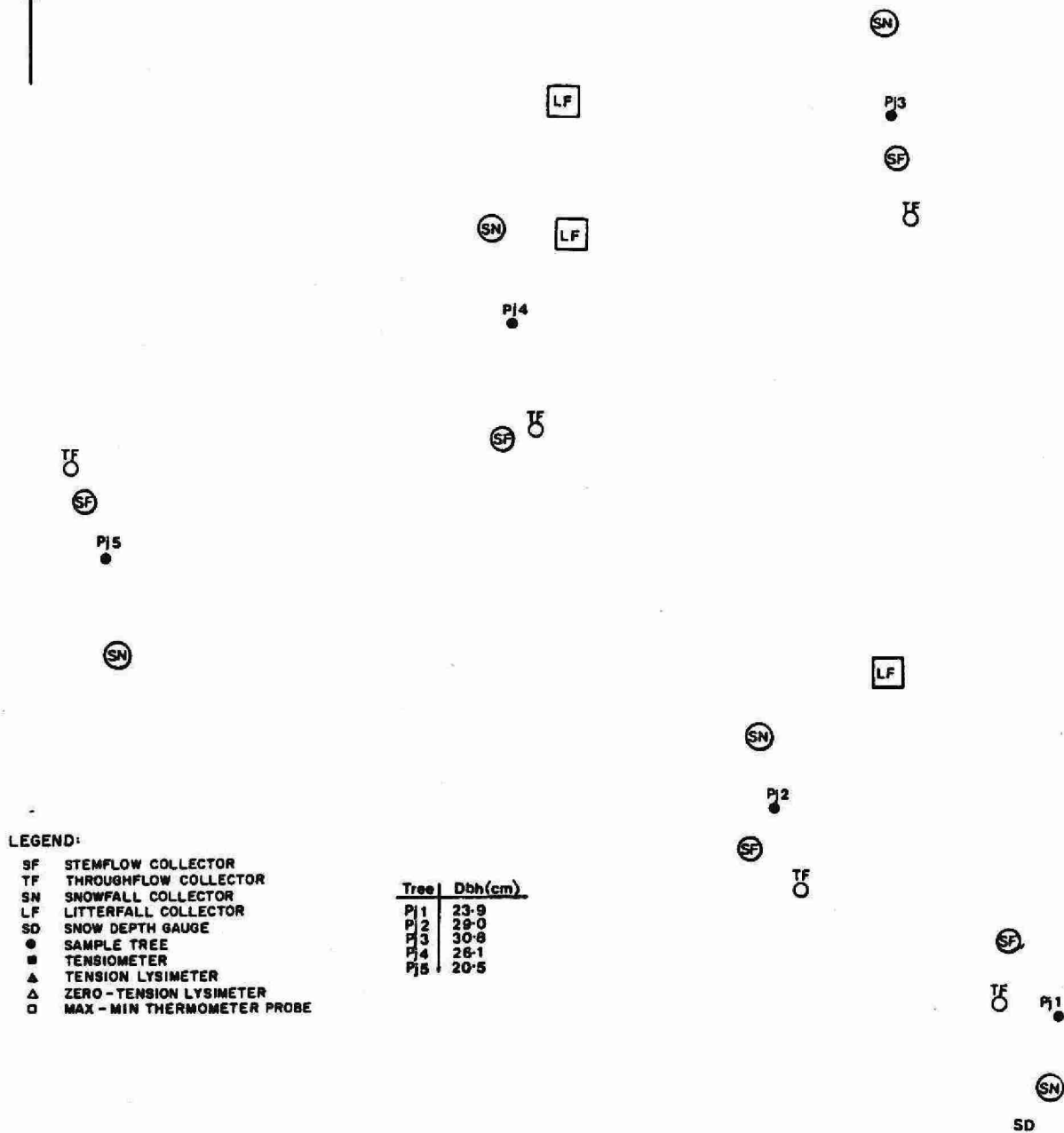
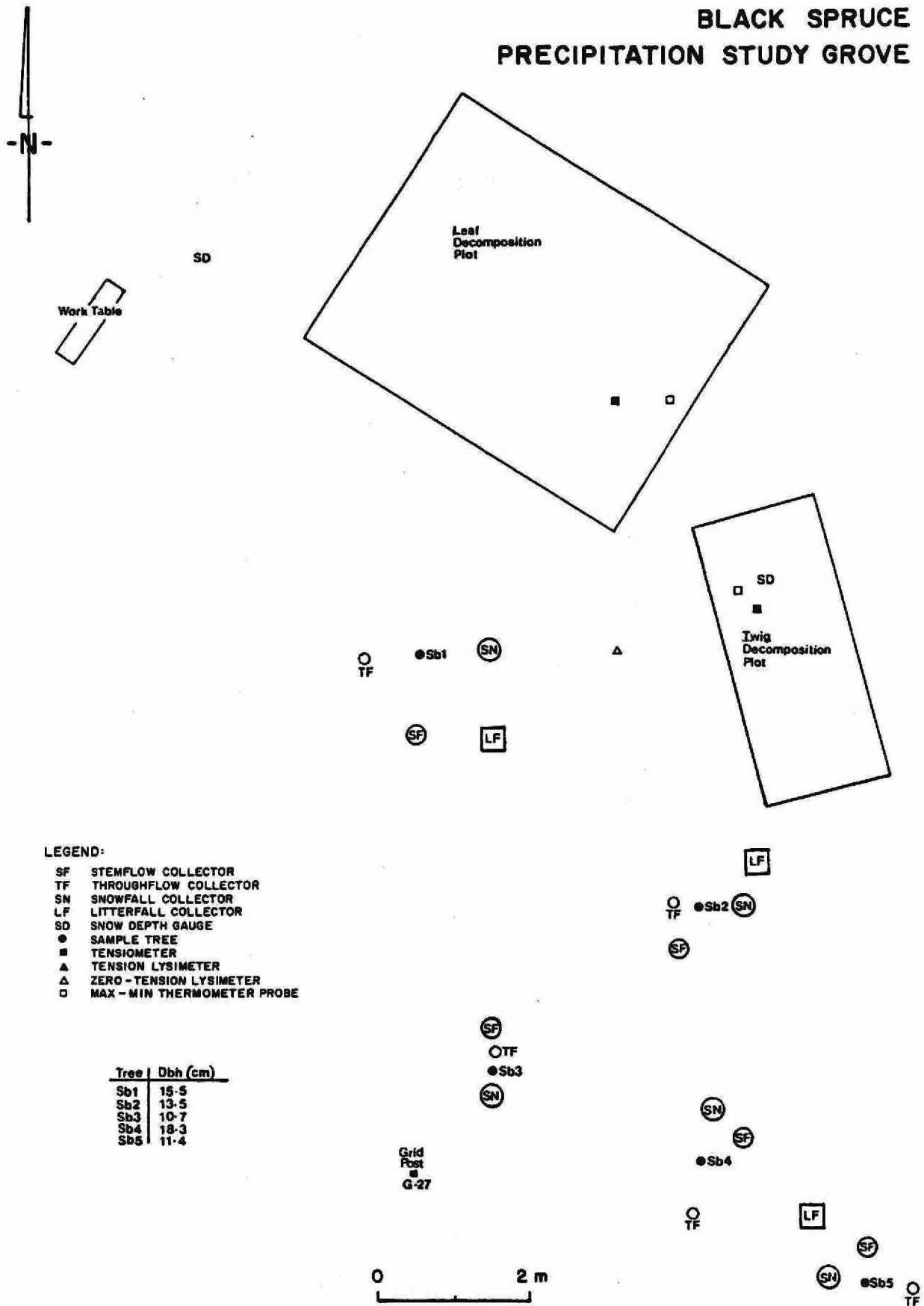


FIGURE 12
BLACK SPRUCE
PRECIPITATION STUDY GROVE



1.7 Data Collection

Data collection at Hawkeye Lake, like at the other biogeochemical sites, requires different sampling regimens for various types of data.

The once-only studies (Section 2) are done to obtain types of data (such as site topography and site soil distribution) which are not likely to change over the life of the biogeochemical project. These studies are scheduled in an irregular way so as to fit into the more regular sampling regimens. Field work for most of these studies has been completed.

The rainfall event monitoring (Section 3) is also of an irregular nature. Data for this monitoring are collected no more than 24 hours after every discrete rainfall event, except during the winter period when rainfall event monitoring ceases. Incident rainfall is measured only at one point, at the instrument platform, whereas throughfall and stemflow are measured at all of the groves.

Fixed interval monitoring (Section 4) is carried out on a variety of regular schedules. Snowfall for example is measured on a weekly basis whereas snowpack core samples are taken only prior to and during the spring snow melt. Incident precipitation and dry deposition are monitored only at one point, at the instrument platform. Most other items are monitored at several locations.

Continuous monitoring (Section 5) is done for ground water level (at a stilling well) for streamflow (at the weir recorder) and for air quality and meteorology (at the instrument trailer). Continuous monitoring, unlike rainfall event and some fixed interval monitoring continues year-round and is not interrupted by winter.

The actual field protocol for monitoring activities is described in Appendix A. A visit log book is maintained in the trailer.

1.8 Laboratory Analyses

All of the chemical analyses, except for some pH and conductivity checks, are carried out by the MOE. The work is carried out by the Inorganic Trace Contaminants Section (ITC) and the Water Quality Section (WQS), Laboratory Services Branch.

The samples collected in the field are collected and submitted in accordance with MOE procedures as detailed in the MOE's Outline of Analytical Methods (1981) and Field Procedures Manual (1983) and APIOS' Terrestrial Effects Procedures Manual (1983).

Each sample is identified with a seven digit location code (see Appendix C) and its own unique sample number. Each is submitted with an appropriate laboratory information service (LIS) Request for Analysis form which specifies which analyses are required. The tests usually required and their LIS code names are listed in Appendix D. Details on tests performed up to January 27, 1986 are given in Sections 2 to 5.

All aqueous samples to be analyzed for trace metals are filtered through a Millipore filter, preserved with HNO_3 and refrigerated until there are sufficient samples for shipment.

The total number of analyses done each year for Hawkeye Lake varied substantially because of the changing demands of once-only studies and precipitation event monitoring. For the 1984-1985 contract year, as an example, 20,818 analyses were done for the biogeochemical studies at Hawkeye Lake.

1.9 Data Storage and Management

Field and laboratory measurements such as volumes, fresh and dry weights, temperature, tensiometer, pH, conductivity, and depth readings are recorded on field sheets and in log books. Duplicate copies are kept on file at Lakehead University.

All of the laboratory data for chemical tests are entered by the analysis laboratory into the MOE Sample Information System (SIS) database on the MOE IBM 370 mainframe. A quality assurance programme was initiated in 1985 to ensure that all relevant Hawkeye Lake data have been accurately recorded on the SIS database.

Since July, 1985 forms were completed and sent to SIS to identify Station Description Codes for all samples types from the Northwestern Region. Two hundred and four LIS reports received to date by Lakehead University were examined for errors in sample numbers, station description codes, and sample collection dates. The chemical test results were also visually inspected for obvious errors. Correction forms have been completed and are being processed in Toronto by System Operations of the MOE. Verification of information on LIS reports will continue as the reports are received.

Once the data have been set up correctly on SIS, computer programs may be applied to test for outliers within the data sets.

Prior to 1985 there was no direct interface between the Hawkeye Lake consultants and the SIS database. Data management at Lakehead University was done by retyping laboratory analysis results onto a small Rainbow computer. Since December, 1985, SENES has been able to directly access the SIS database and is currently importing the data into a second database using FOCUS, a fourth generation computer language.

SIS is a generalized database system that contains data from a variety of studies. It provides a centralized data structure into which laboratory analysis can be routed and stored. Since it is very general, it is difficult to retrieve data in a format consistent with the nature of the data. For example, at present the Southern Ontario data are retrieved from SIS using a SPSS (Statistical Package for the Social Sciences Format). COBOL programs are then written to extract data from these files and to format them into a useful form. This is a time consuming and expensive process. In general, in terms of reformatting data, the speed, economy and flexibility of third generation languages like COBOL or FORTRAN is limited.

It is desirable to maintain central SIS data storage for acid deposition data. However, for the purposes of management and analysis of data, another database utilizing a fourth generation computer language is desirable.

1.10 Data Analysis

Data analysis for Hawkeye Lake, like data management, is still at an early stage. This is particularly true when compared to the work done at Harp Lake and Plastic Lake. However, work at these watersheds started earlier.

Some data analysis is contained in the Hawkeye Lake Biogeochemical Study Site Preliminary Report (1985) and the 1984-1985 Annual Report. Several reports containing a substantial amount of data analysis are scheduled for completion in the near future.

1.11 Other Studies

The contractors for the Hawkeye Lake Biogeochemical Site have also been responsible for carrying out Terrestrial Effects Programme tasks within the Northwestern Region. Most of this work was done in connection with soil and vegetation baseline studies and primarily involved the collection and preparation of samples for analysis. A specific part of this work was a study of bedrock, soil and vegetation around eight acid sensitive lakes in Pukaskwa National Park. Sampling around the lakes took place from 1983 to 1985 and a final report was produced in March, 1986. In addition, a poster on the Pukaskwa study was presented at the Muskoka '85 International Symposium on Acidic Precipitation.

A project on the effects of acidic precipitation on the moss-humus layer, conducted by a graduate student at Lakehead University, Mr. G. Vanson, is underway at the Hawkeye Lake site.

Chapter 2

ONCE - ONLY STUDIES

2.0 ONCE-ONLY STUDIES

2.1 Site Delimitation and Topography

Purpose

In order to determine nutrient budgets within the watershed it is essential that the boundaries of the watershed and hence its area be determined as precisely as possible. Accurate mapping of the watershed is also essential in locating sampling stations. Topography is a basic parameter of the watershed whose determination is useful for many of the other activities.

Field Activities

In the fall of 1982 ground observations were used to complement aerial photography interpretation and a preliminary determination of the watershed boundary was made. In the spring of 1983 permanent ground markers were put in place to designate the watershed boundary.

Starting in the spring of 1983 a reference grid was established on the watershed to coincide with the UTM grid. Grid lines were determined and marked every 50 m (see Figure 13). The grid was completed in the spring of 1984 but improvements in the grid markers in the field were carried out into 1985.

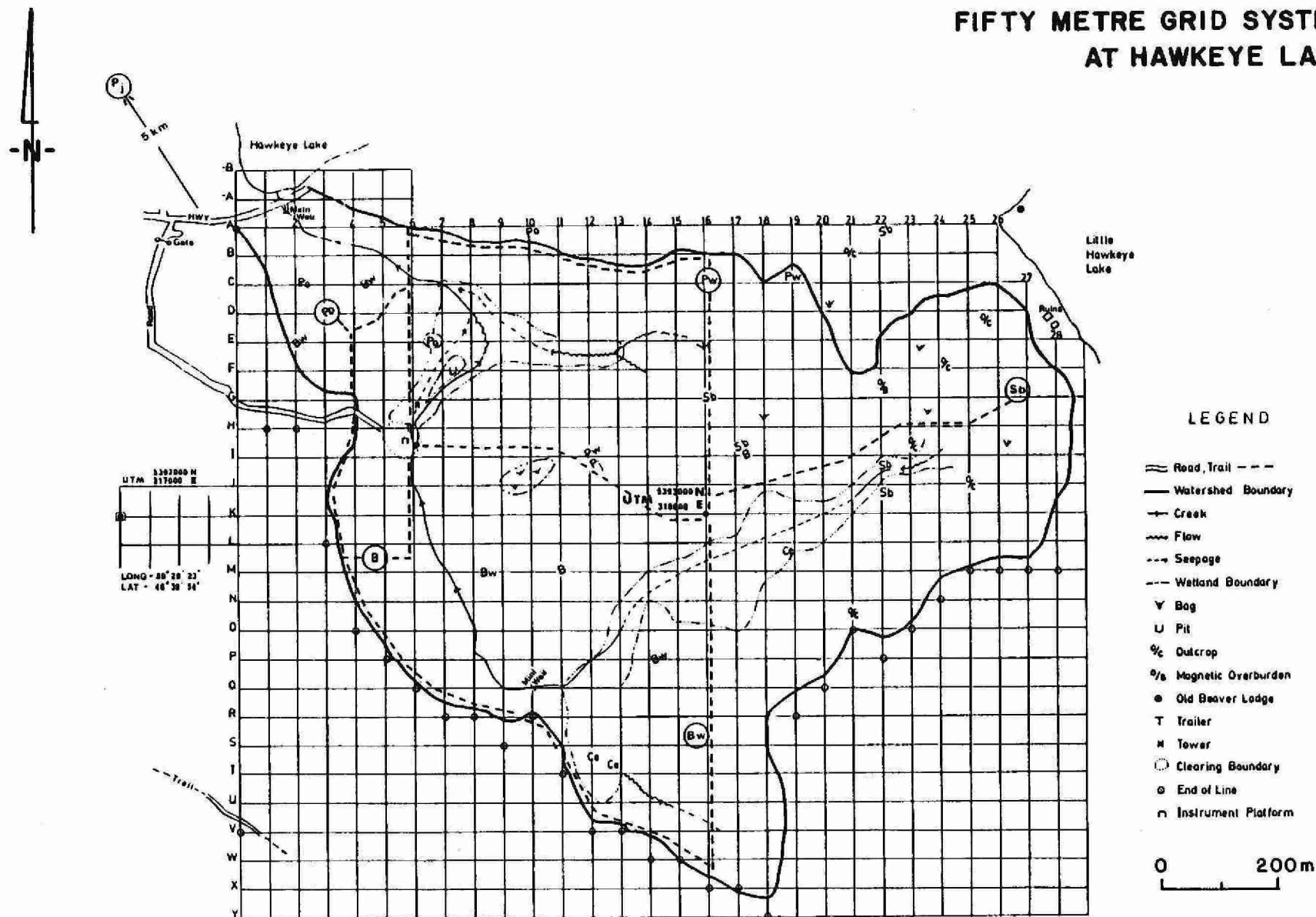
A topographic survey of the watershed was started in 1983 and completed in 1984. Elevations were determined at each 50 m interval intersection point on every second north-south grid line.

Lab Analyses

Not applicable.

FIGURE 13

FIFTY METRE GRID SYSTEM AT HAWKEYE LAKE



Data Storage and Management

Not applicable.

Data Analysis

Topographic maps of the watershed with 2,4 and 10 m contours were produced (see Figures 14, 15 and 16). The area of the watershed was calculated as being 97 ha.

Comments

Work satisfactorily completed.

FIGURE 14

TOPOGRAPHIC MAP OF HAWKEYE LAKE
BIOGEOCHEMICAL STUDY SITE
TWO METRE CONTOURS

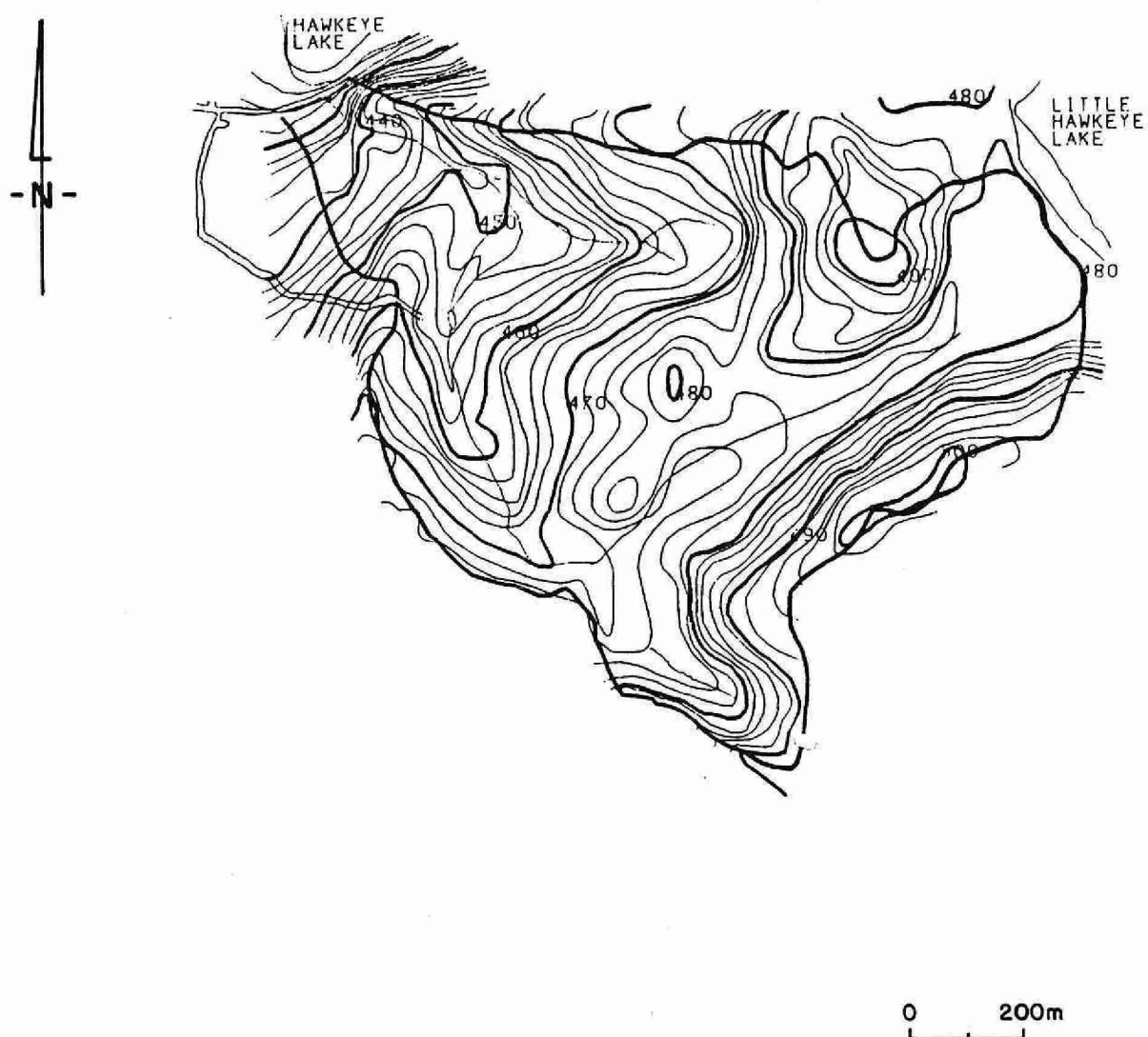
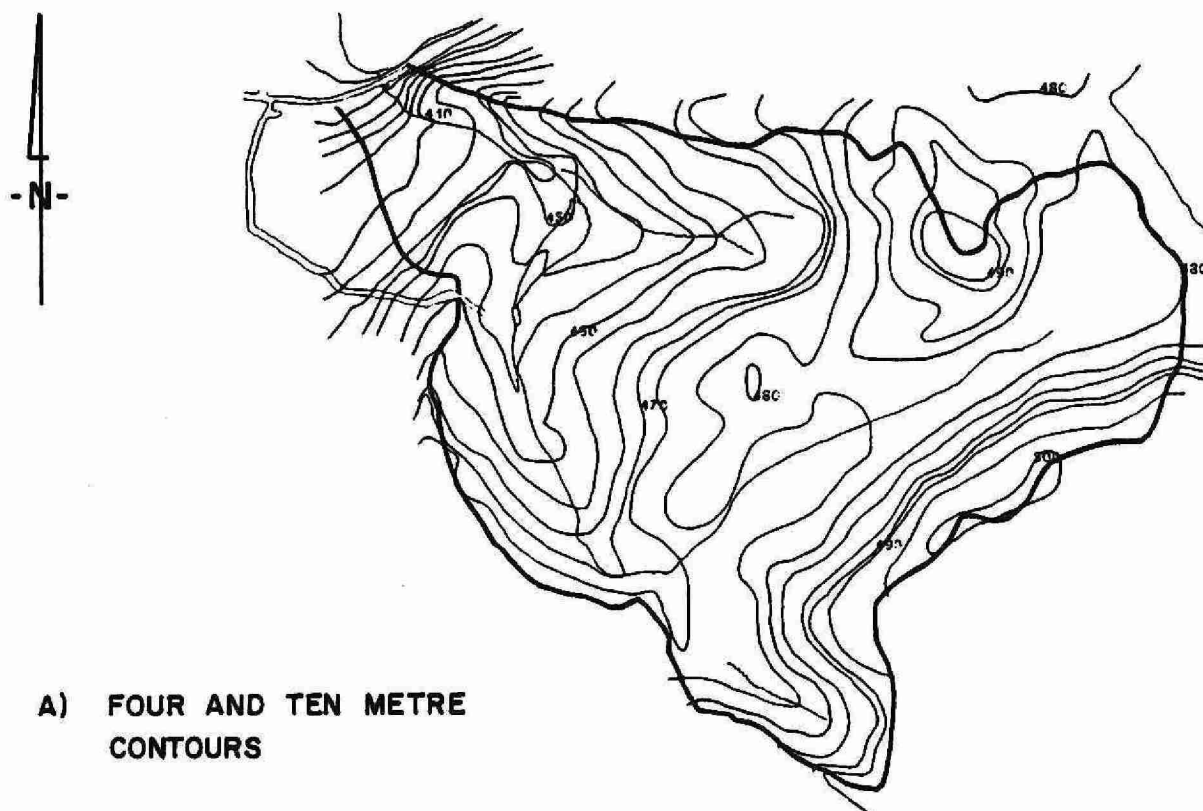


FIGURE 15

TOPOGRAPHIC MAPS OF HAWKEYE LAKE
BIOGEOCHEMICAL STUDY SITE
FOUR AND TEN METRE CONTOURS



B) TEN METRE CONTOURS

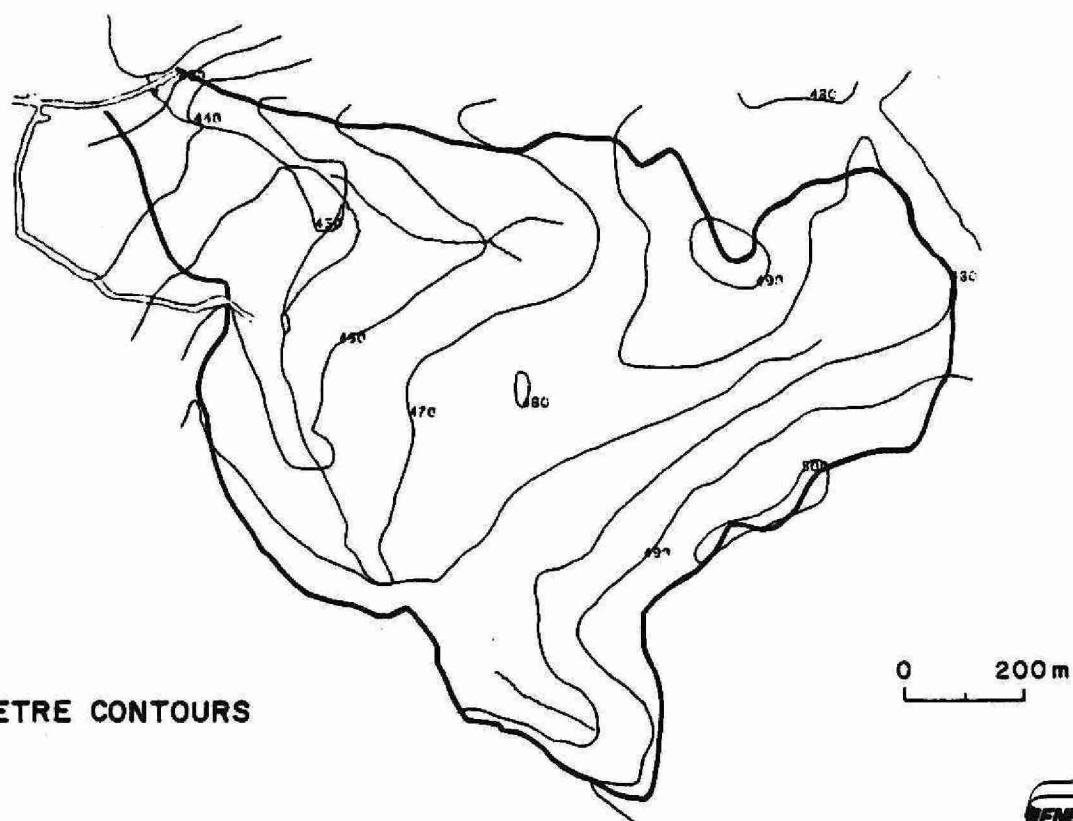
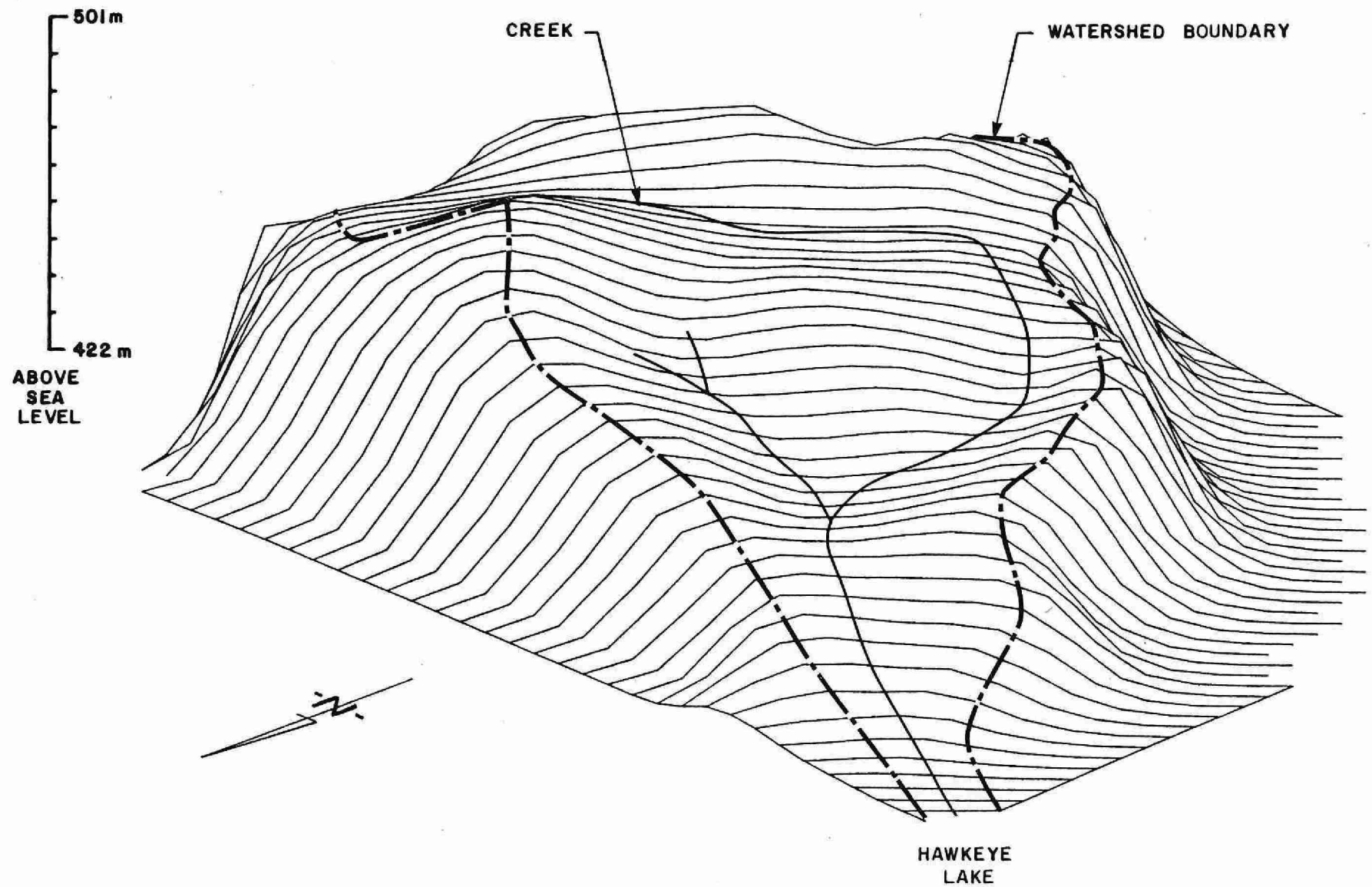


FIGURE 16
OBLIQUE PERSPECTIVE OF TOPOGRAPHY



2.2 Seismic Survey

Purpose

A seismic survey is necessary to help contour the bedrock surface and hence determine the soil mass of the watershed, one of the key determinants in the overall nutrient budget. The seismic survey is also necessary to help determine the underground limits of the watershed and perhaps the groundwater pattern.

Field Activities

During the summer of 1983, a preliminary plate and hammer seismic survey of the watershed was carried out by MOE staff. Sixteen soundings were taken at points on the periphery of the watershed (See Figure 17).

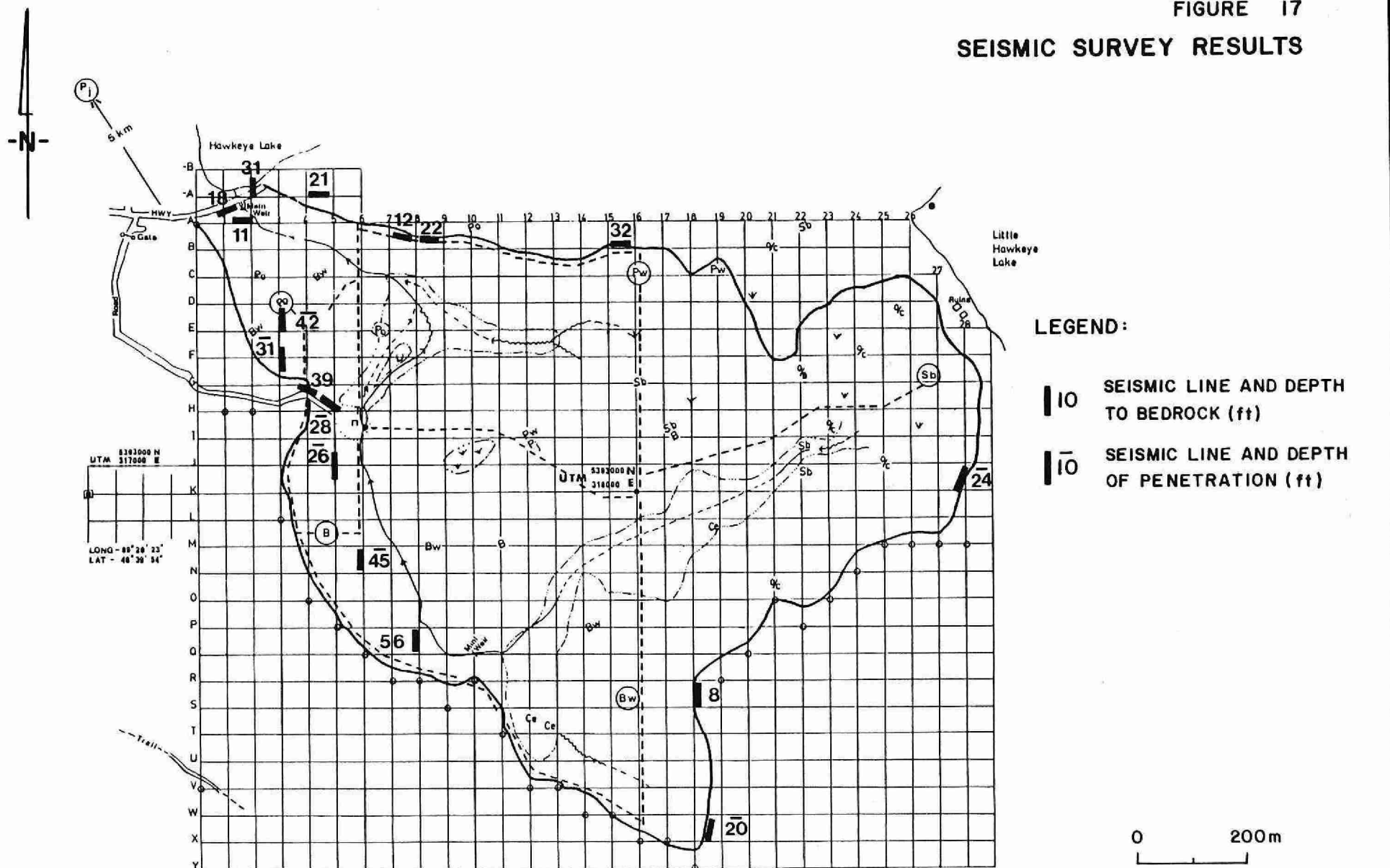
Lab Analyses

Not applicable.

Data Storage and Management

Depth to bedrock was determined for part of the watershed and plotted on a map (see Figure 17).

FIGURE 17
SEISMIC SURVEY RESULTS



Data Analyses

The report by MOE staff concluded that, except at the eastern end of the watershed, plate and hammer seismic techniques could not provide a true picture of the overburden thickness or interpret the bedrock topography.

Comments

Additional work is probably necessary to obtain an accurate estimate of the soil mass.

2.3 Soil Survey

Purpose

Knowledge of soil depth and soil types and their distribution is necessary for several reasons. Determination of the soil mass and soil chemistry is necessary for establishing the watershed nutrient budget. The distribution of soil types is also useful to determine the causal relationships between vegetation and soil types on the watershed and to further describe the watershed for comparison with other areas.

Field Activities

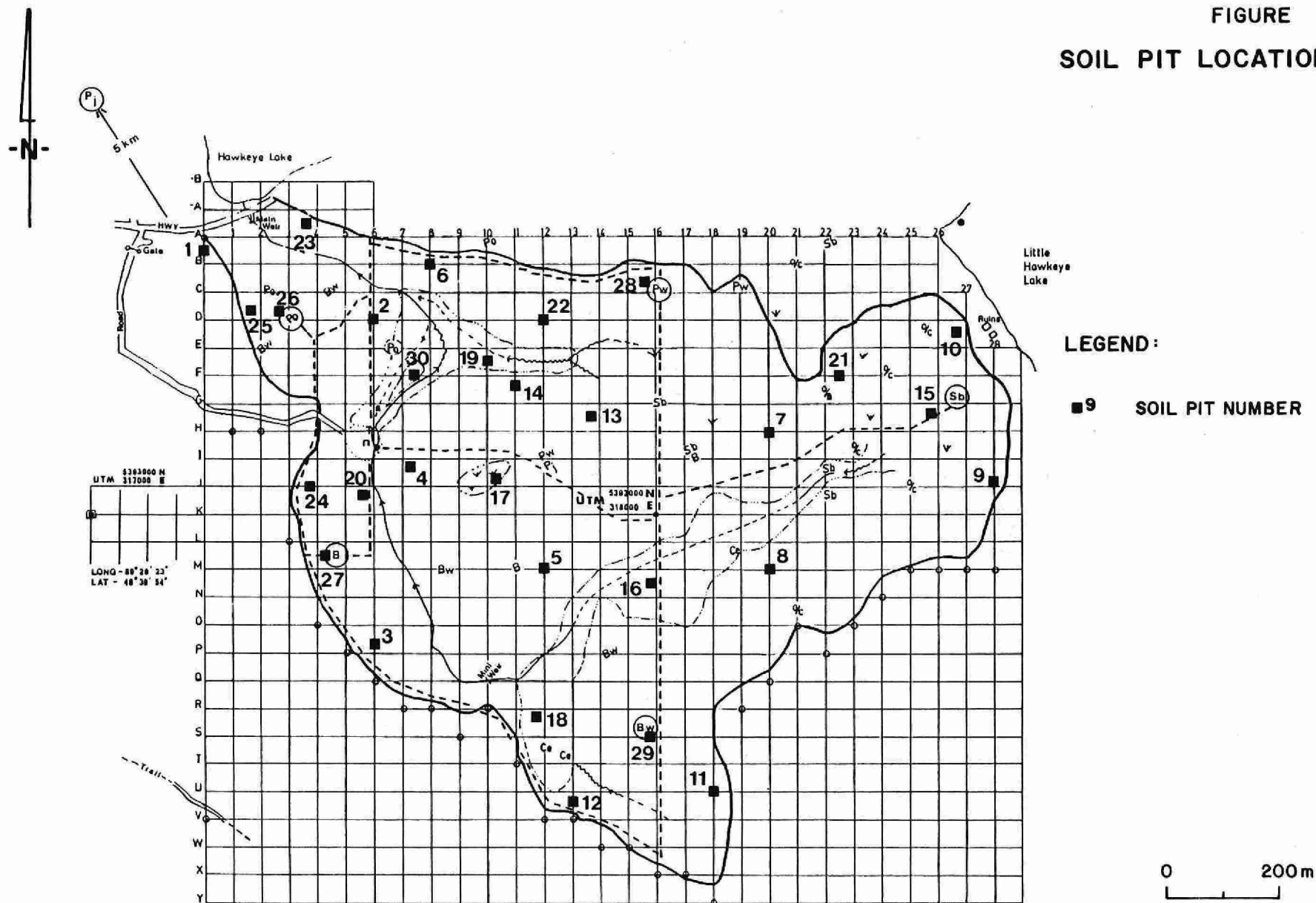
During the fall of 1984 soil samples were taken from 25 soil pits throughout the watershed, chosen to represent the different mapping units determined by field and air photo reconnaissance surveys (see Figure 18). At each site a 1 m² pit was dug to the parent material and a field description form filled out.

Triplicate soil samples of the A, B and C horizons were taken and transported to the laboratory for analysis.

Laboratory Analyses

Soil tests were carried out at Lakehead University on some of the samples for moisture, bulk density, rubbed fibre, gravel content and buffering capacity. Two hundred and thirty-six samples have been sent to the MOE laboratory. Tests to be done were PHEW, PHECA, CAESC, MGESC, KKESC, ALESC, CEC, FEEDI, FEEPY, ALEDI, ALEPY, CCU3UR, NNTKUR, SS04EW, SAND, SILT, CLAY, ALECA, ORGC, CUUT, ZNUT, PBUT AND NIUT. As of January 27, 1986 no analysis results had been received for this soil survey.

FIGURE 18
SOIL PIT LOCATIONS



Data Storage and Management

Tests performed at Lakehead University are on file.

Data Analysis

No data analysis has been done to date.

Comments

Further chemical analyses on plant nutrient availability for the soil survey have been discussed but no decisions have yet been made.

Work on the geology of the watershed may be useful to help determine chemical movement from the parent material to soil.

2.4 Hydrological Survey

Purpose

A field survey of water seepage and other observable groundwater features is necessary for the establishment of the hydrological monitoring system (see 4.8) and as part of the general description of the watershed. Some of the information may also be of value in helping determine the overall water budget for the watershed.

Field Activities

Field surveys were carried out in May, 1984 with MOE staff assistance. Additional surveys were done in the summer of 1985 especially looking at seepage close to the stream banks. Field determinations of groundwater elevation, temperature, pH, conductivity, odour and colour were made.

Laboratory analysis

Not applicable.

Data Storage and Management

Field measurements are on file.

Data Analysis

See 4.8.

Comments

Some additional work may be necessary in conjunction with 4.8.

2.5 Forest Inventory

Purpose

A statistically valid description of the tree species, their basal areas, densities and distribution is necessary for determining which species to single out for sampling groves and standing crop biomass studies. The forest inventory data are also essential for interpreting the grove and biomass results and for extrapolating them to the watershed as a whole and therefore allow an overall watershed budget to be produced. The forest inventory can also be useful for comparisons with results from the topographic survey and the soil survey allowing for a better understanding of the causal factors affecting the distribution of features within the watershed.

Field Activity

A 1% reconnaissance survey was carried out the fall of 1982 using circular plots of 0.04 hectares regularly spaced in a 200 x 200 m grid. Based on this survey groves for white birch, trembling aspen, balsam fir and white pine were selected for monitoring in 1983. The first three species are the dominant ones in the watershed. White pine is a species common to all biogeochemical study sites. The selection of the groves was based on presence of pure stands of trees representative of diameter classes for the species. The original white birch grove was replaced in April, 1984 by a better grove and additional groves for black spruce and jack pine were added in 1985.

In the spring and summer of 1983 a 5% forest inventory was carried out using a Bitterlich variable plot system with a 2 factor metric prism. In all, 373 points were sampled using the 50 m grid to locate sampling points in a regular pattern. In addition to the Bitterlich basal area determination, selected trees at each point were measured for diameter and height.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on file and on the Lakehead computer.

Some data have been tabulated (Tables 4 and 5).

Data Analysis

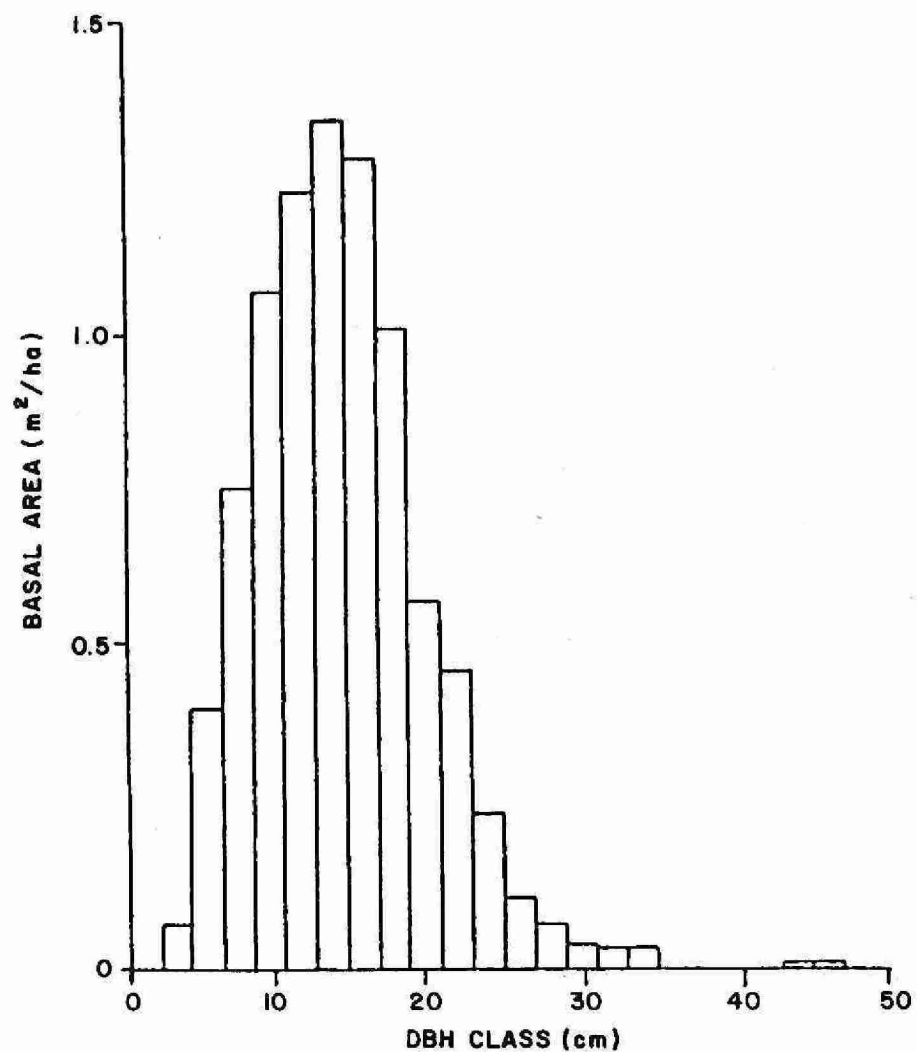
White birch, balsam fir, trembling aspen and black spruce are the dominant tree species on the watershed accounting for over 90% of the basal area and number of stems in the watershed. White spruce, white pine, cedar, jack pine and larch account for most of the remainder. More than 60% of the basal area for the four dominant tree species is found in the 10 to 20 cm diameter classes (see Tables 4 and 5).

Tree distribution maps were made for the dominant tree species with each sample point ranked according to numbers of trees for each species. Maps were also made showing basal area distribution (see Figures 19 to 26).

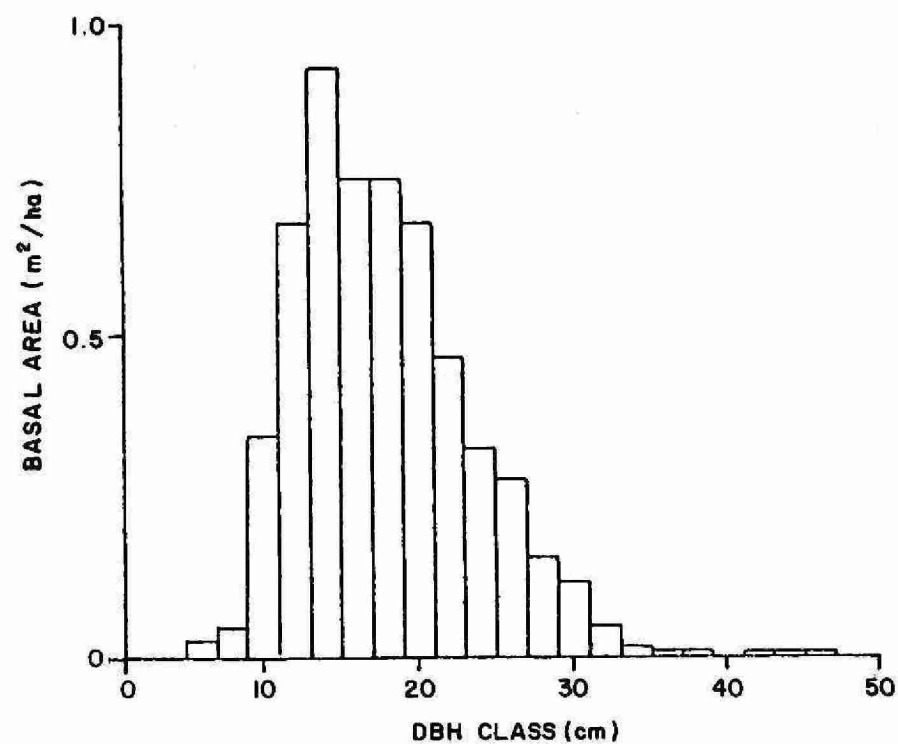
White birch and balsam fir are found throughout most of the watershed. Trembling aspen occurs principally in the central and northern area. Black spruce and white pine are more localized and found primarily in the northeast.

A draft status report on the forest inventory and forest biomass/bioelements studies was completed in March, 1986.

TABLE 4

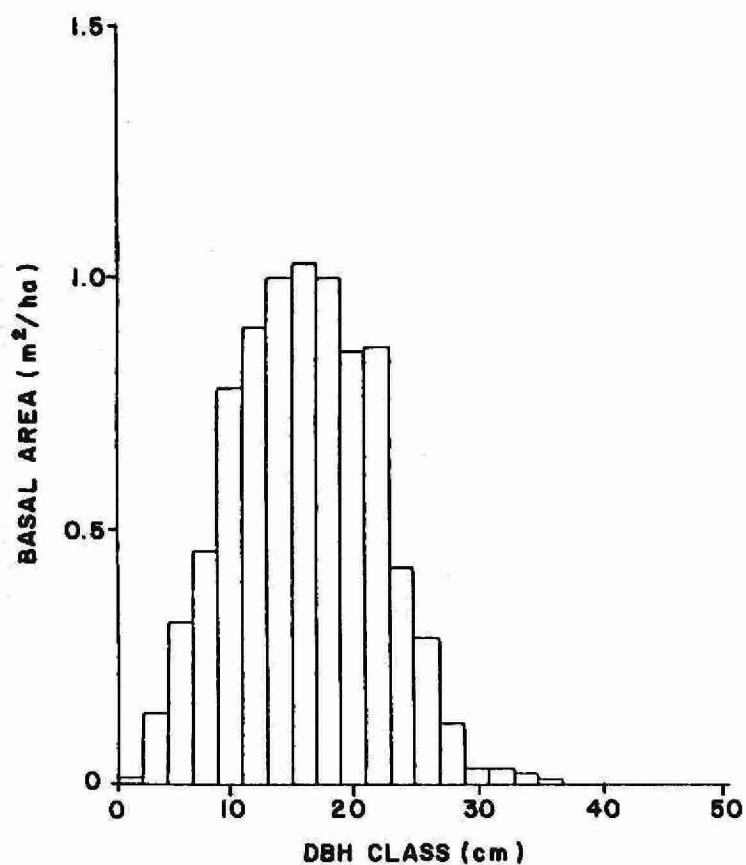
BASAL AREA - DIAMETER DISTRIBUTION
WHITE BIRCH AND TREMBLING ASPEN

A) WHITE BIRCH

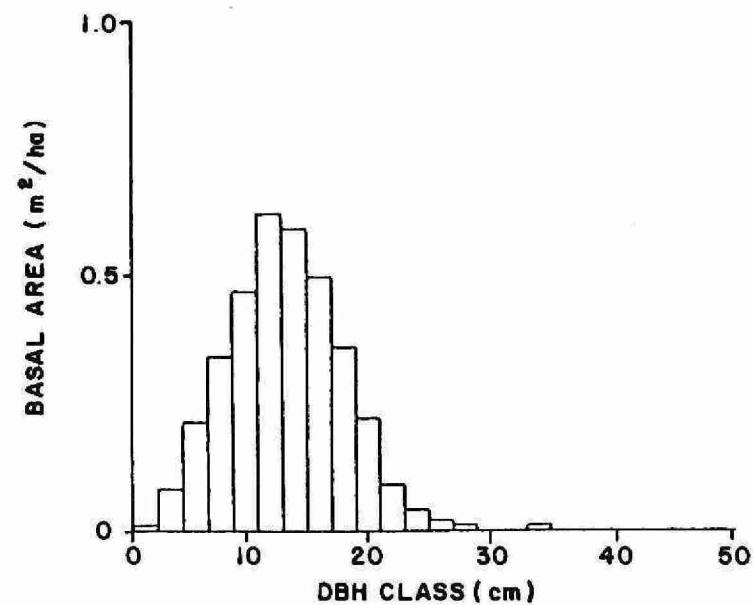


B) TREMBLING ASPEN

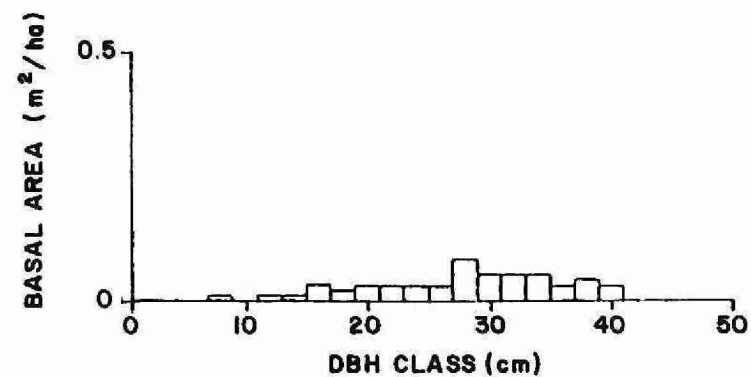
TABLE 5

BASAL AREA-DIAMETER DISTRIBUTION
BALSAM FIR, BLACK SPRUCE AND WHITE PINE

A) BALSAM FIR



B) BLACK SPRUCE



C) WHITE PINE

FIGURE 19
MAP OF TOTAL TREE BASAL AREA

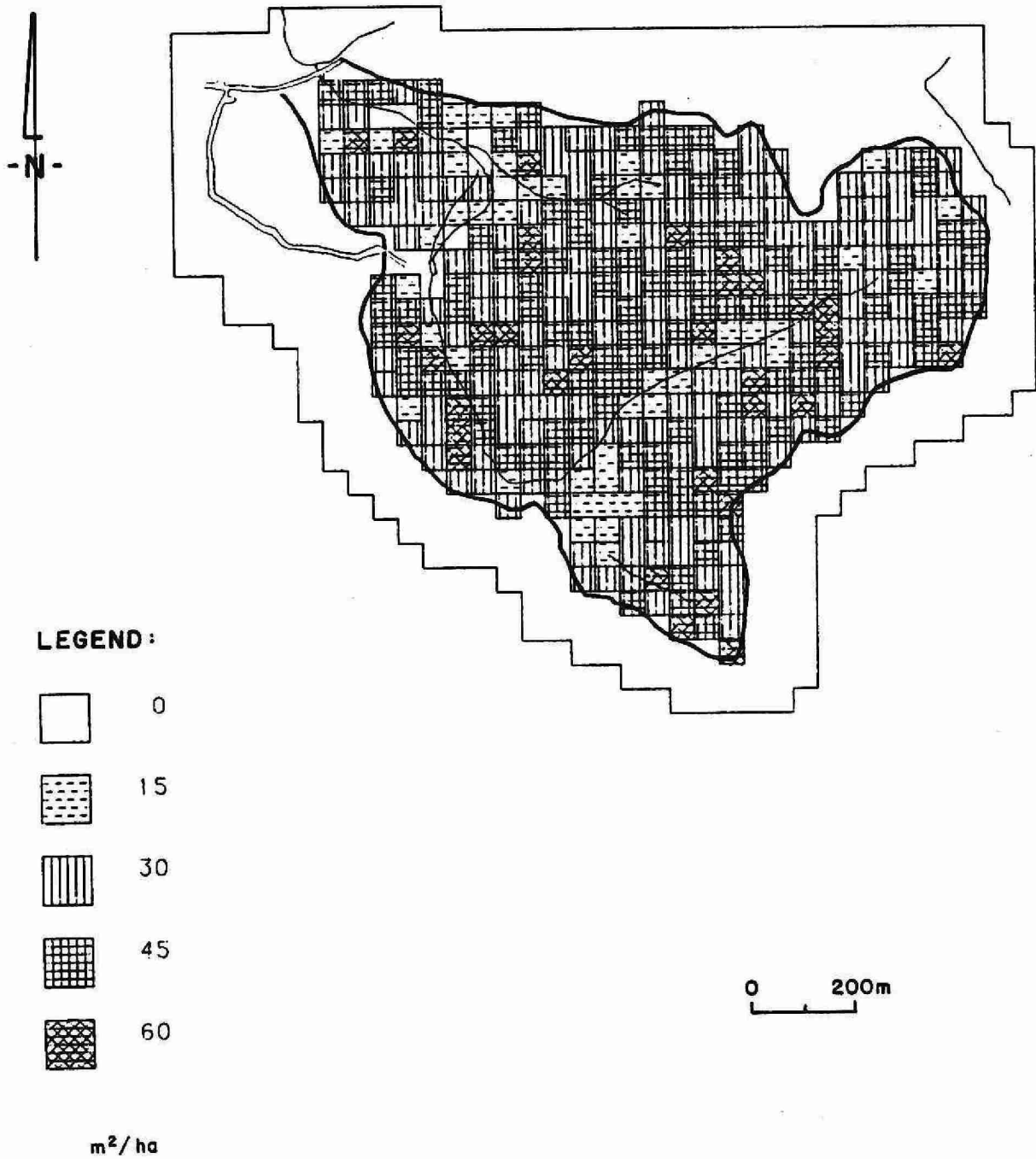
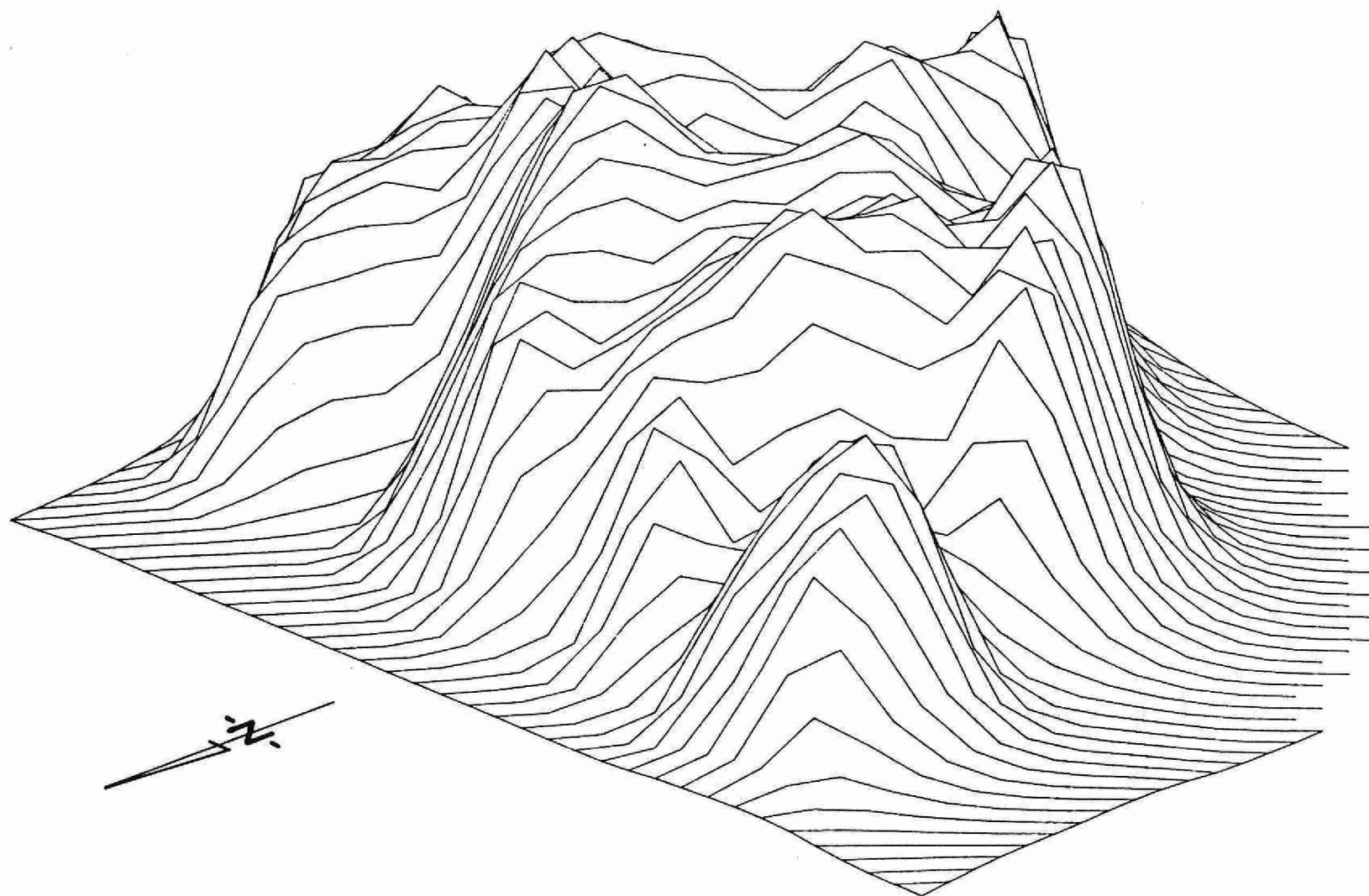


FIGURE 20
OBLIQUE PERSPECTIVE
OF TOTAL TREE BASAL AREA

62
1
 m^2/ha



MAP OF BLACK SPRUCE BASAL AREA

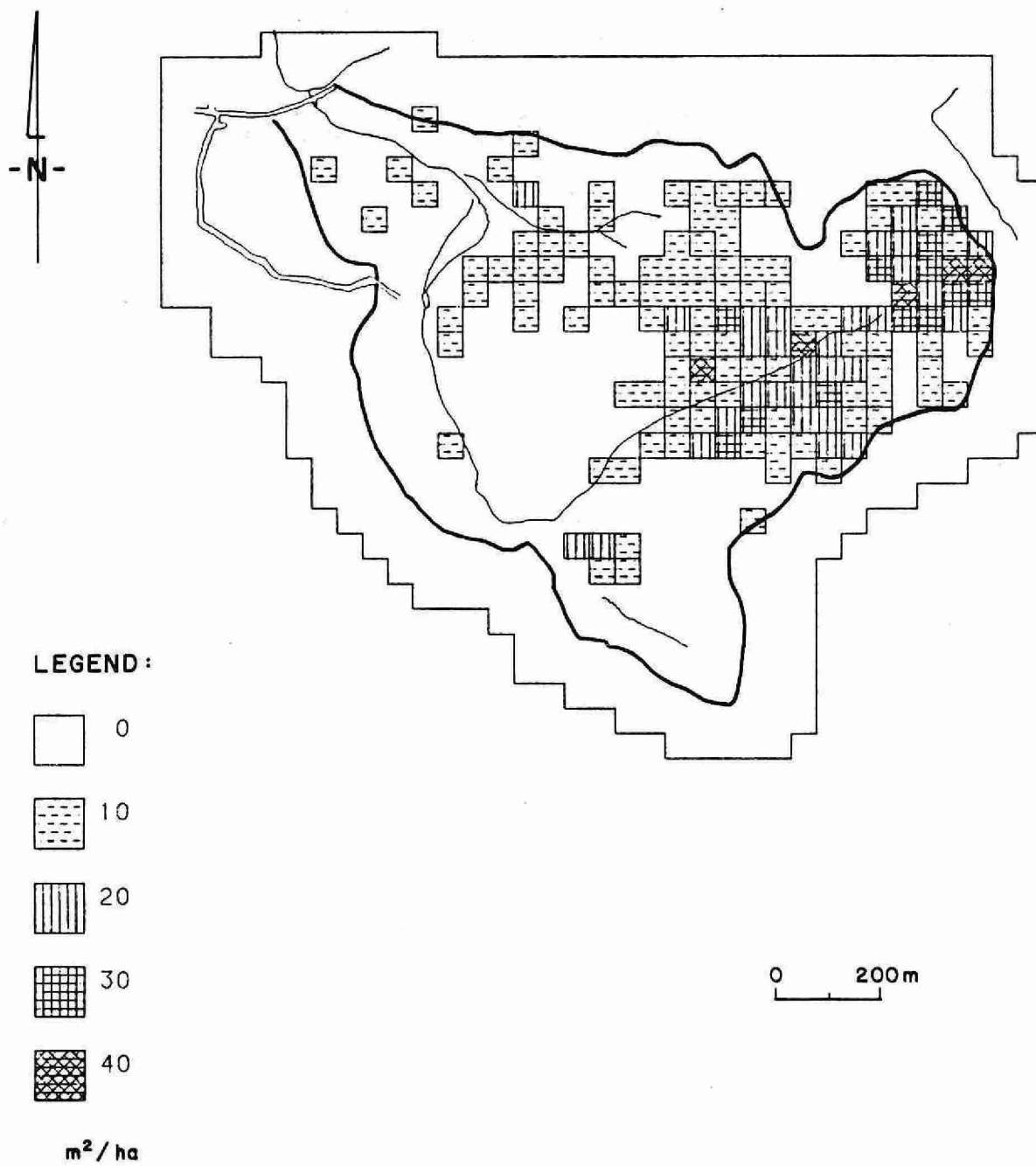


FIGURE 22
OBLIQUE PERSPECTIVE
OF BLACK SPRUCE BASAL AREA

40

1
 m^2 / ha

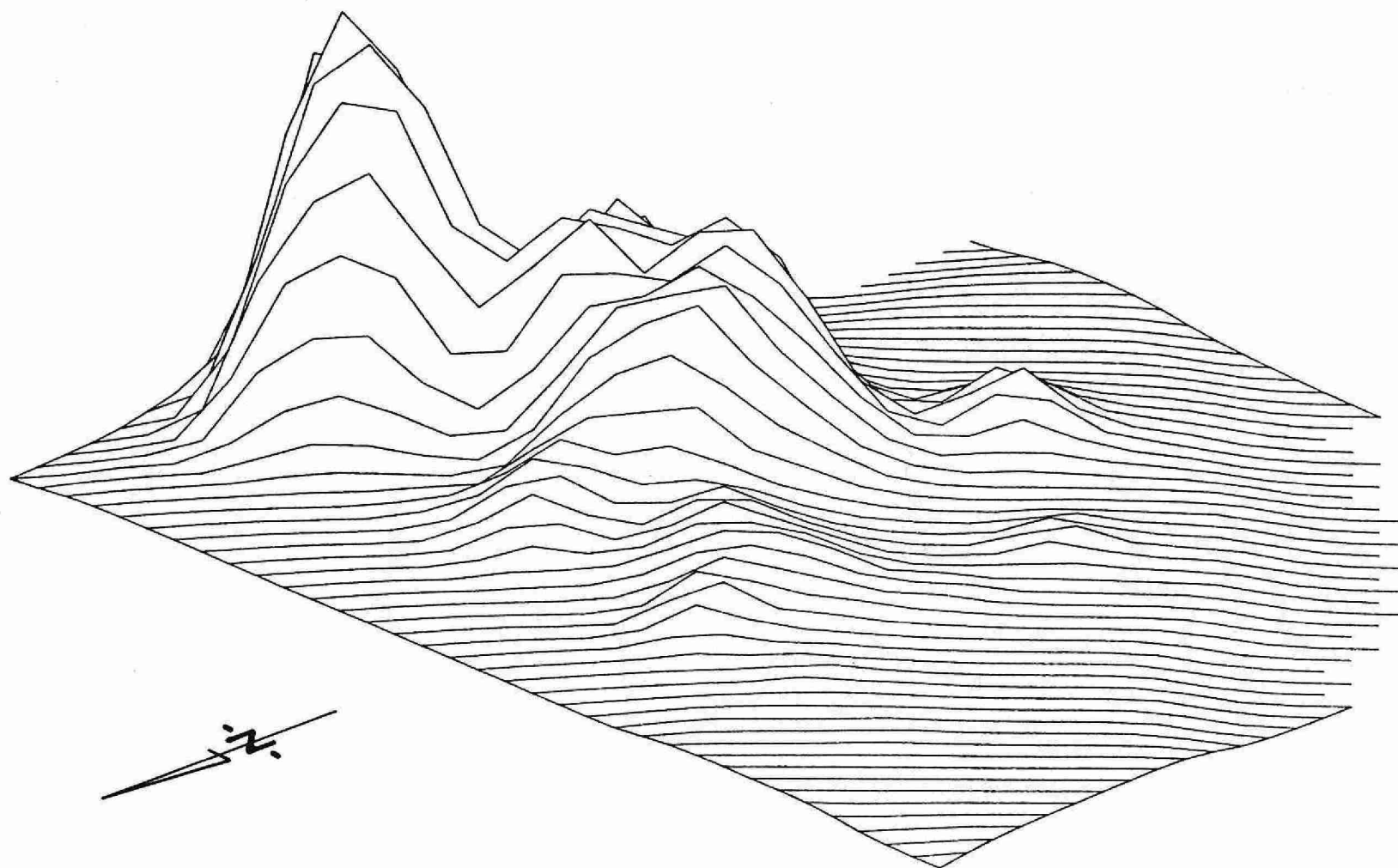
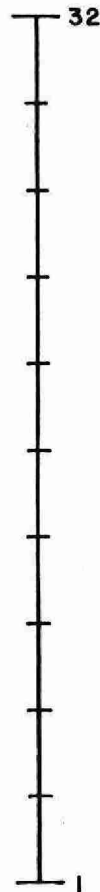


FIGURE 23

OBLIQUE PERSPECTIVE
OF BALSAM FIR BASAL AREA

32



m²/ha

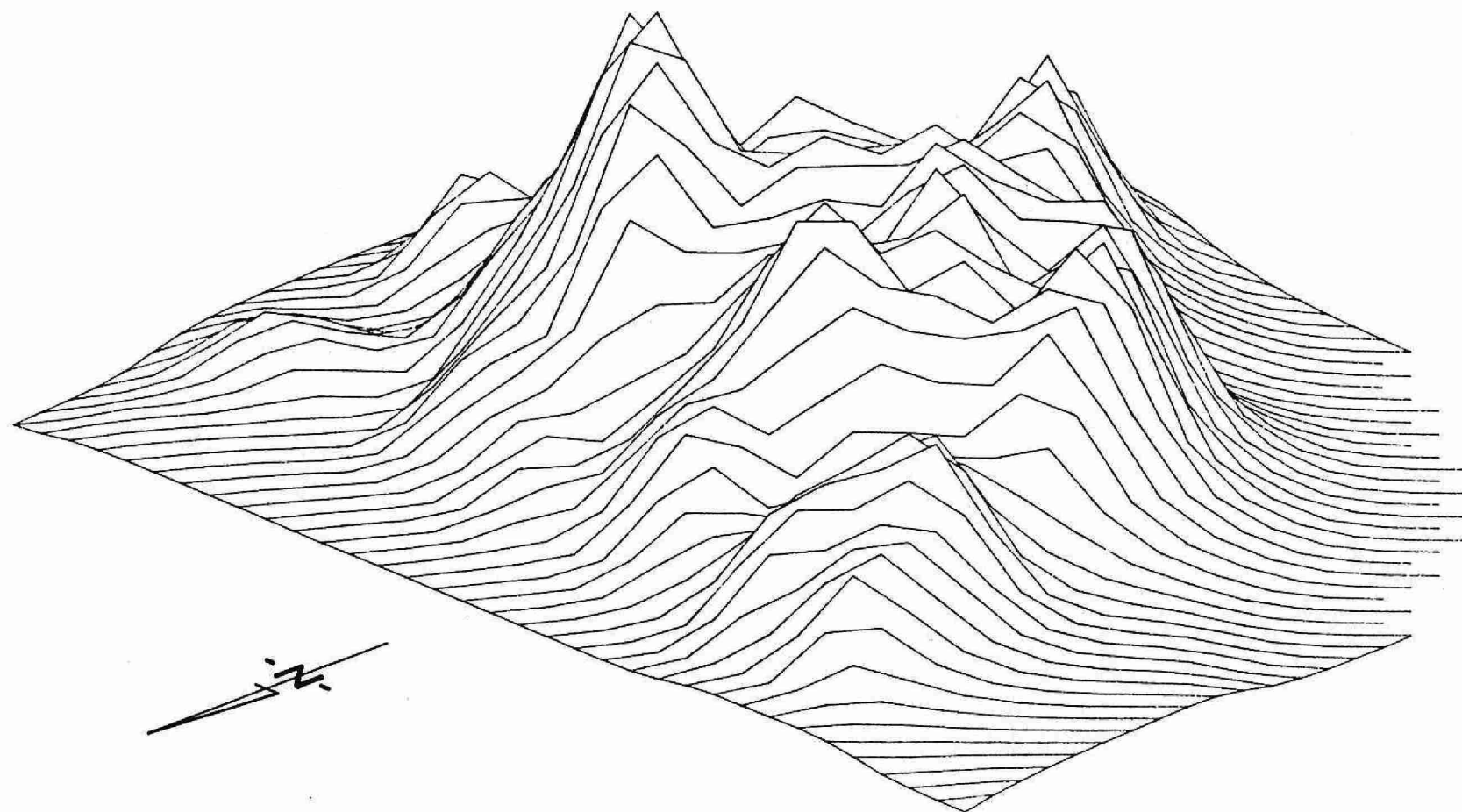


FIGURE 24
OBLIQUE PERSPECTIVE
OF WHITE PINE BASAL AREA

18
1
 m^2/ha

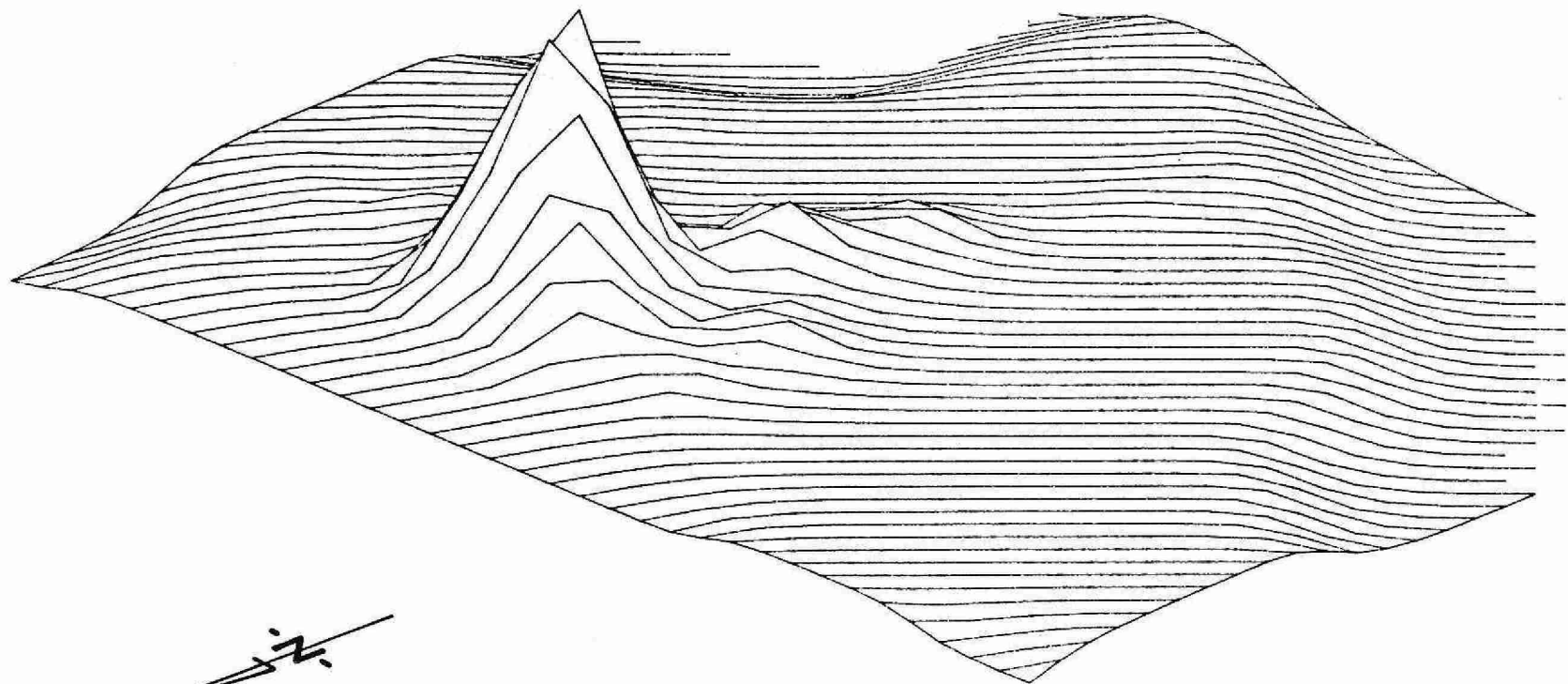
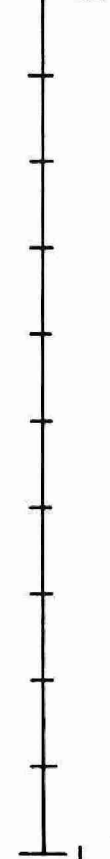


FIGURE 25

OBLIQUE PERSPECTIVE
OF TREMBLING ASPEN BASAL AREA

32



m²/ha

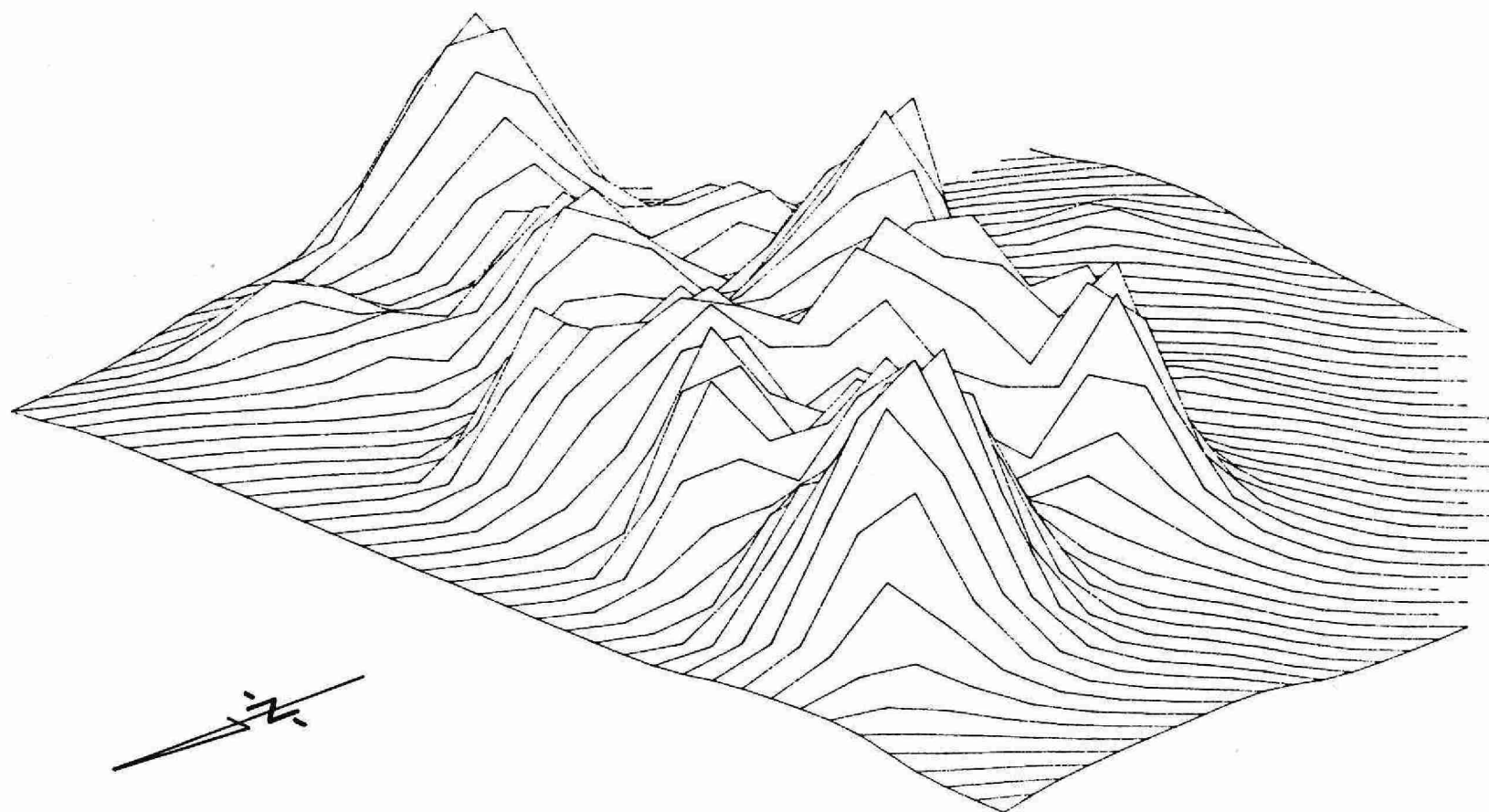
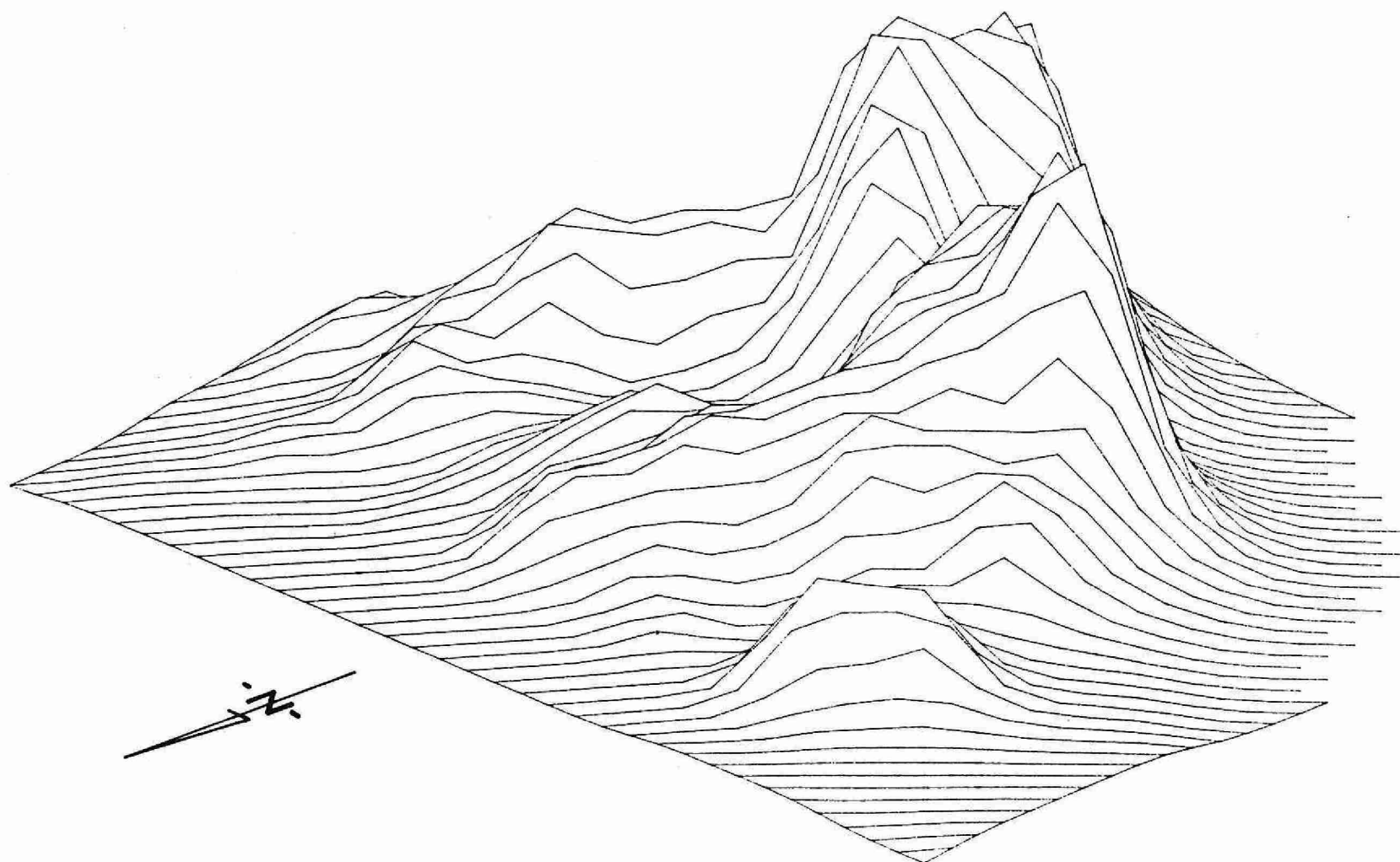


FIGURE 26

OBLIQUE PERSPECTIVE
OF WHITE BIRCH BASAL AREA

42

1
 m^2/ha



Comments

A comparison between the 1% reconnaissance survey data and the 5% survey data shows marked differences, clearly indicating that the 1% survey data would have been inadequate for use in the biomass calculations. The use of the reconnaissance survey data in choosing the dominant trees for representation in groves poses no problems as the four dominant species are the same in the two surveys. It was originally reported that this more detailed survey comprised 10% of the watershed but recalculations during 1985 have shown that in fact it was 4.8%.

A shrub inventory has been proposed to complement the tree inventory. It would be useful in terms of assessing the shrub throughfall data and determining the importance of the shrub layer biomass in modifying throughfall chemistry and in contributing to watershed nutrient fluxes and reserves.

No attempts have yet been made to relate forest inventory data to grove monitoring data. This will have to be done in order to determine watershed nutrient fluxes. An intermediate stage whereby forest types are mapped may be required.

2.6 Standing Crop Biomass Study

Purpose

A large part of the watershed nutrient reserve is in the tree biomass. In order to calculate the overall watershed nutrient balance it is therefore necessary to determine the quantities of each major nutrient located within the tree biomass.

Field Activities

Five sample trees of each of the four dominant species from just outside the watershed along the access road were selected for destructive sampling in 1984. The sampling was to determine fresh and dry biomass data for trees of the main size classes and to sample the component parts of the trees for chemical composition.

The trees were cut in the summer of 1984. The component parts (needles or leaves, bark, cones, dead branches, small branches, large branches, roots and stems) were first weighed in the field and subsamples then transported to Thunder Bay.

Laboratory Analyses

The subsamples were oven dried to obtain a dry weight/fresh weight ratio. Subsamples were also ground and sent to the MOE laboratory for chemical analysis. In all, 446 samples were sent from November, 1984 to March, 1985. All analyses on these samples have been completed. Tests done were FEUT, MNUT, PPUT, NNTKUR, ALUT, CAUT, CDUT, CLUT, CUUT, KKUT, MGUT, MOUT, NAUT, NIUT, PBUT, SSUT and ZNUT.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Other data are on file.

Data Analysis

A report is currently being written and a draft status report was completed in March, 1986.

Chapter 3

RAINFALL EVENT MONITORING

3.0 RAINFALL EVENT MONITORING

3.1 Incident Rainfall

Purpose

Incident precipitation is the key outside input to the watershed water and nutrient budgeting. It must be accurately determined in order to construct the budgets. Event incident rainfall data is also needed to compare with event canopy and shrub throughfall and stemflow data to determine the effect of the biomass interfaces on the incident rainfall chemistry.

Field Activities

Incident rainfall collectors were installed on the instrument platform during the summer of 1983 according to siting criteria established for the APIOS network and have been monitored since. The collectors consist of an "Aerochem Metric" precipitation collector and five identical funnel collectors of 0.065 m² collecting area each. The "Aerochem Metric" is used to monitor wet deposition only whereas the funnel collectors monitor both wet and dry deposition. Precipitation volume and pH are measured in the field for each collector and samples are then submitted for chemical analysis.

In addition in the spring of 1984 a tipping bucket recording rain gauge was installed next to the instrument platform. This recorder gives additional information on intensity and duration of rainfall events. A standard rain gauge is also read after each rainfall event.

Incident precipitation is not measured in the groves.

Laboratory Analyses

Seventy-nine Aerochem samples have been collected and sent to the MOE lab from July 25, 1983 to January 27, 1986. Sixty-six funnel collector samples were

collected and sent to the MOE lab from September 30, 1983 to January 27, 1986. The funnel collector samples are pooled samples. Prior to June 17, 1985 these five samples were pooled on an equal volume basis. From June 17, 1985 to July 25, 1985 duplicate proportional and equal volume pooled samples were collected and sent for analysis. Beginning on August 6, 1985 all samples were pooled on a proportional basis to conform with the other biogeochemical studies in Ontario. As of January 27, 1986, analyses had been completed for all funnel collector samples and all but one aerochem samples. Tests done for both Aerochem and incident rainfall were ALUT, FEUT, MNUT, ZNUT, pH, ACDG, CLIDUR, CAUR, MGUR, NAUR, KKUR, SS04UR, NN03UR, NNHTFR and PP04FR.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some laboratory analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Some tabulation of data has been done (Tables 6 and 7).

Data Analysis

An analysis of incident precipitation (including snowfall) from October 1983 to September 1984, done for a comparison with white pine throughfall and stemflow, showed an average pH value of 4.78. Values for key constituents are shown in Tables 8 and 9. These values suggest that precipitation is a significant source of hydrogen, sulphate, nitrate and ammonium for the watershed.

A preliminary analysis done in 1983 showed that pH values vary widely for each precipitation event, partly dependent on precipitation volume which is highly variable as shown on Tables 6 and 7. Analyses done in 1984 suggest some significant differences between the Aerochem Metric and the funnel collector

TABLE 6
PRECIPITATION EVENTS
(SEPTEMBER 1983 - SEPTEMBER 1984)

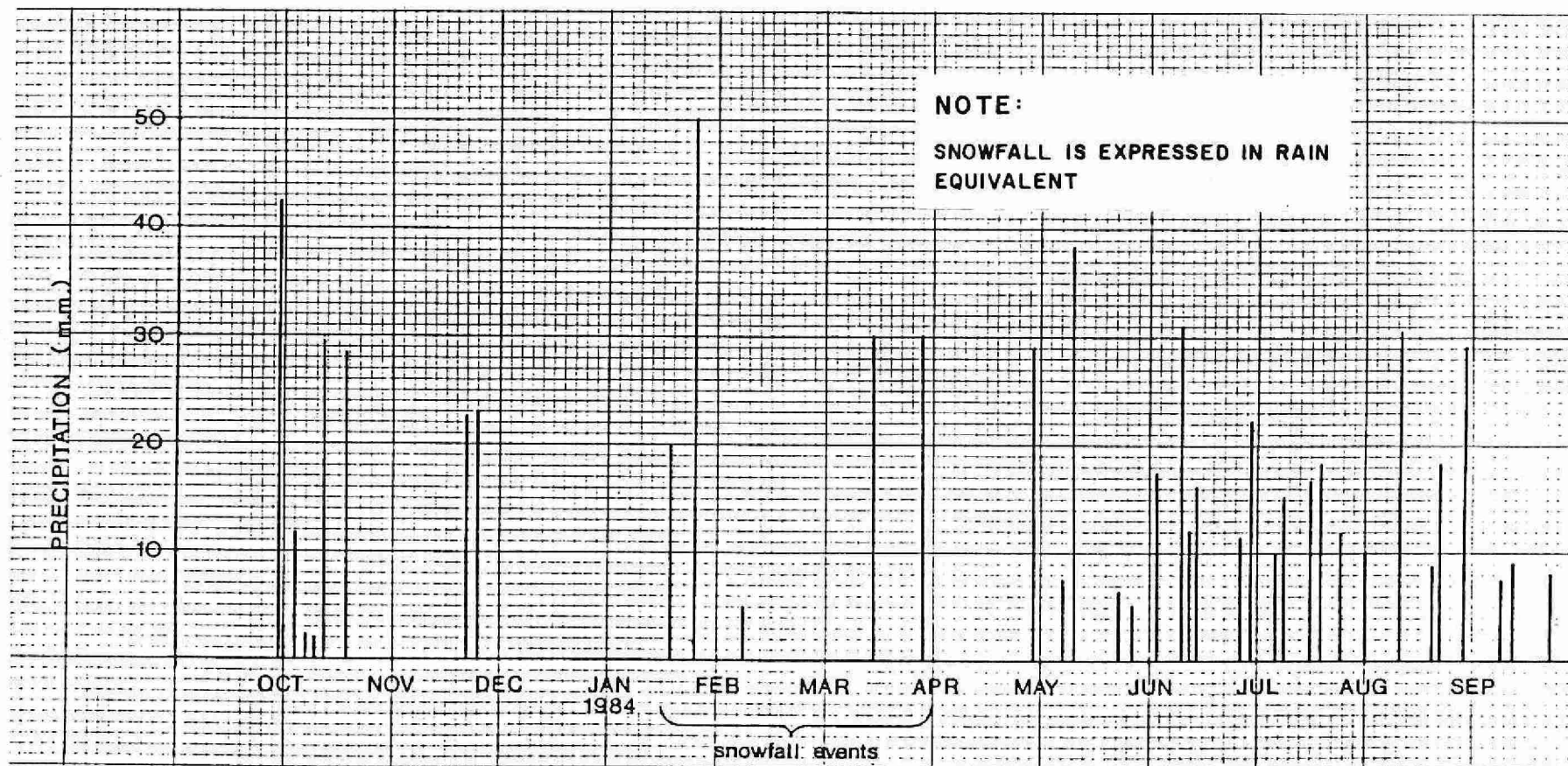


TABLE 7
PRECIPITATION EVENTS
(OCTOBER 1984 - OCTOBER 1985)

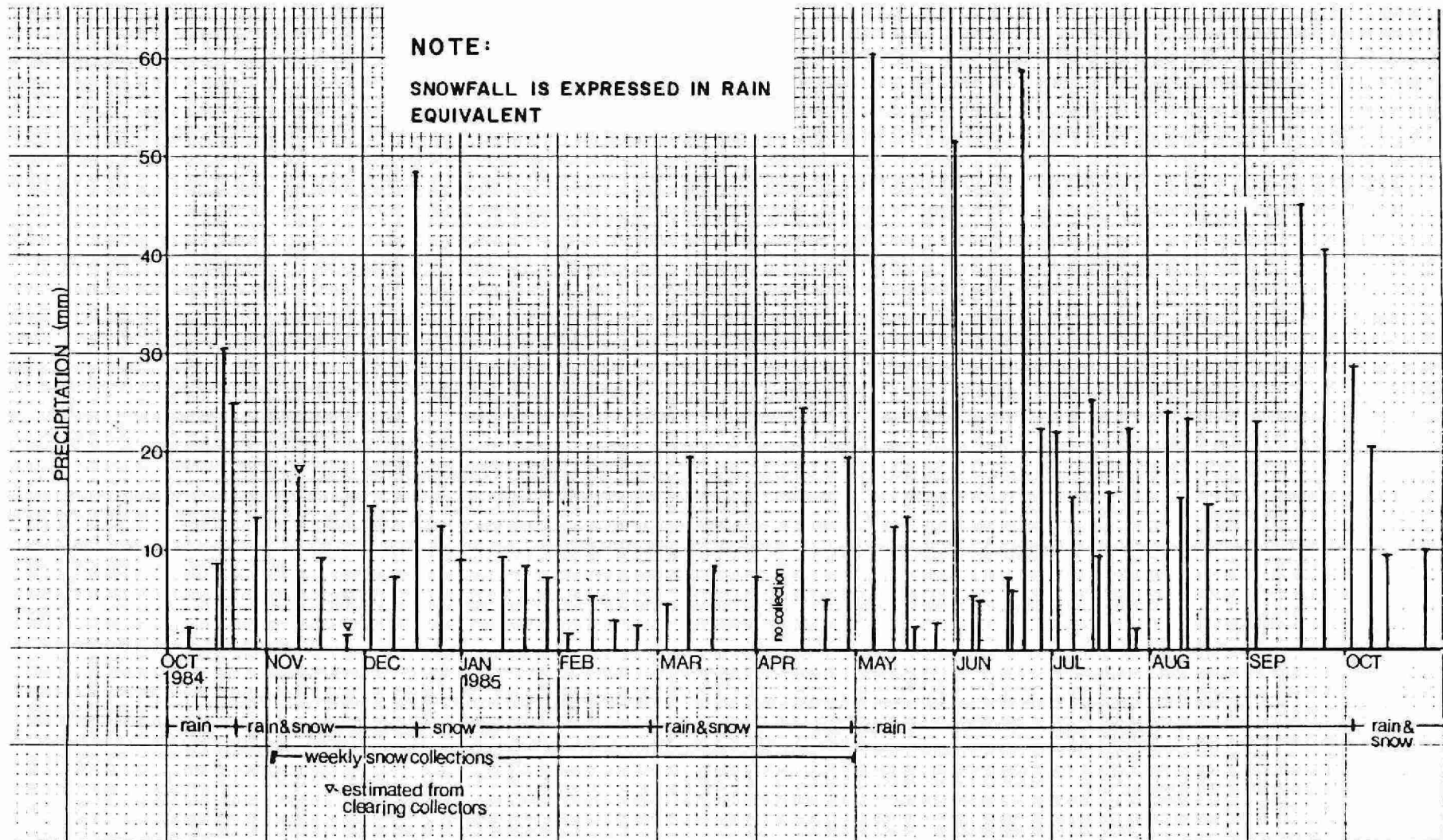


TABLE 8

INCIDENT AND WHITE PINE
THROUGHFALL DEPOSITION
(OCTOBER 1983 - SEPTEMBER 1984)

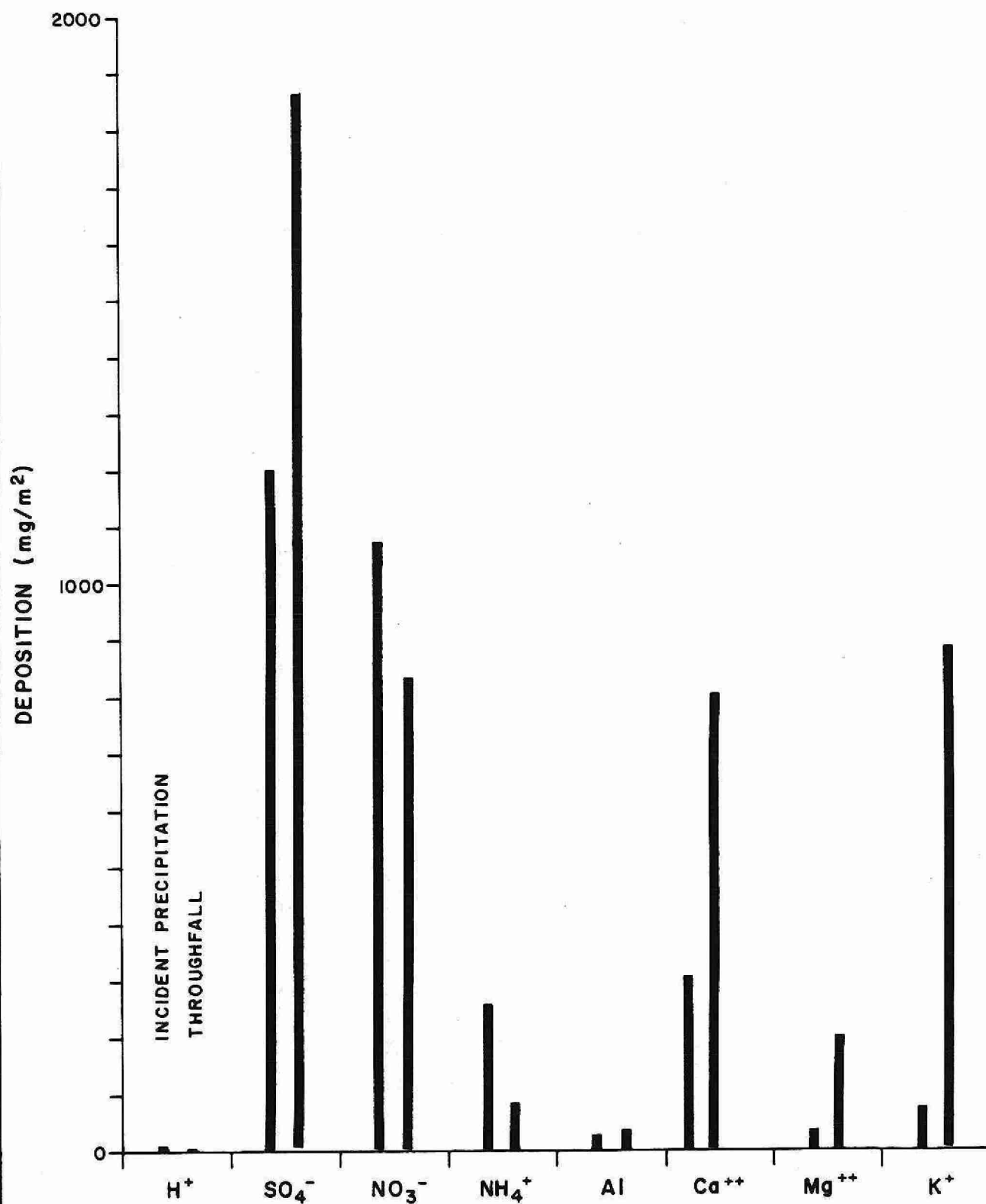
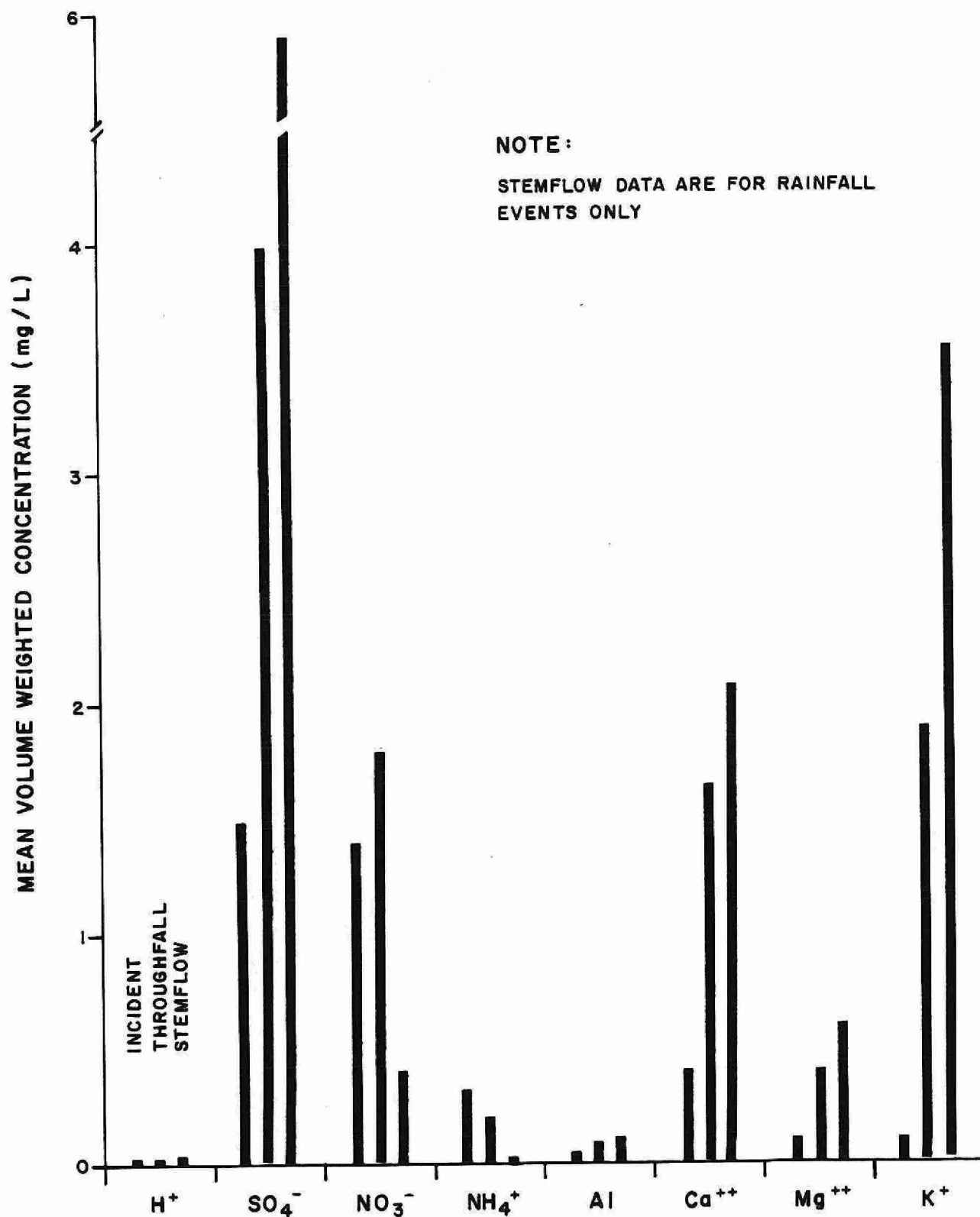


TABLE 9

INCIDENT AND WHITE PINE
THROUGHFALL AND STEMFLOW CHEMISTRY
(OCTOBER 1983 - SEPTEMBER 1984)



samples for certain chemical tests.

Event by event comparisons were made for ions found in Aerochem Metric samples collected during 14 precipitation events in 1984. High correlation coefficients of several ion pairs indicate that the concentrations of some elements are closely related.

Comments

The use of equal volume pooling for the incident rainfall funnel collectors up to June, 1985 was the result of a different interpretation of instructions. At the other biogeochemical sites proportional pooling had been used. This is also a problem for tree canopy event throughfall (3.2) and stemflow (3.3). A report on the comparison of proportional versus equal pooled data for the summer of 1985 data was completed in March, 1986. Preliminary indications show that there is good correlation between the two sets of data for incident rainfall and throughfall but that there are some possibly significant differences for the stemflow data. In theory the use of equal volume pooling for incident rainfall should not be a problem since the five collectors on the platform are identical. However, the difference in field procedures could have caused some slight differences in results in practice.

The Aerochem Metric sampler also collects snow but the sensor is not reliable enough in winter conditions to give representative collections.

3.2 Throughfall

Purpose

It is well documented that vegetation intercepts a high percentage of incident precipitation in forested regions. Most of the precipitation is intercepted by the canopy of trees and falls to the ground as throughfall after more or less prolonged contact with the leaves and branches. It is also well established that precipitation undergoes chemical changes as it passes through the vegetation, losing some nutrients that are taken up by the plants and gaining others that are leached from the biomass interfaces. Measurement of precipitation throughfall is necessary to qualify and quantify these changes to determine the nutrient budget within the watershed.

Field Activities

Rain throughfall collectors are located at all tree groves and are of two types: canopy throughfall collectors and shrub throughfall collectors.

A canopy throughfall collector was placed under each tree monitored in a grove, on the opposite side of the stem from the snowfall collector (see Figure 6, for example). The canopy throughfall collector is identical to the incident rainfall funnel collectors used on the instrument platform in the clearing. Canopy throughfall collectors were installed at the four original groves in the summer of 1983 and monitoring began then. The white birch grove was relocated to a better stand of trees in April, 1984. In the spring of 1985, collectors were installed and monitoring began in the black spruce and jack pine groves.

Shrub throughfall collectors consist of a series of split plastic tubes placed on the ground under shrub canopies near the tree groves. Shrub throughfall collectors were installed at the white pine, white birch and balsam fir groves in the spring of 1985. Sampling at the three groves began in July, 1985. There are two collectors per grove with a collection area of 0.15 m^2 for each

collector.

Volume and pH for each sample are measured in the field.

Laboratory Analyses

Three hundred and nineteen canopy rain throughfall samples were collected and sent to the MOE laboratory from July 28, 1983 to January 27, 1986. The canopy samples are pooled for each grove. Prior to June 17, 1985 the samples were pooled on an equal volume basis. From June 17, 1985 to September 5, 1985 selected duplicate samples, proportional and equal volume, were collected and sent. Since September 18, 1985, all samples were pooled on a proportional basis.

Thirty-eight shrub rain throughfall samples were collected and sent to the MOE laboratory from July 8, 1985 to January 27, 1986. Tests done for both canopy and shrub throughfall were ALUT, FEUT, MNUT, ZNUT, pH, ACDG, CLIDUR, CAUR, MGUR, NAUR, KKUR, SS04UR, NN03UR, NNHTFR AND PP04FR. All of these samples had been analysed by January 27, 1986.

Date Storage and Management

Laboratory analyses are on SIS and on file.

Other data are on file.

Data Analysis

An analysis of comparative data for stemflow, throughfall and incident precipitation for 16 precipitation events from July 25, 1983 to September 17, 1983 was done. Throughfall pH under broadleaved canopies was higher than the pH of incident rain. Under conifers the pH of incident precipitation showed little change.

A comparison of white pine throughfall and stemflow for the three biogeochemical sites was produced during the summer of 1985 and presented as a poster at the Muskoka '85 International Symposium on Acidic Precipitation. The results showed that at Hawkeye Lake for a total incident precipitation (including snowfall) of 791.2 mm for the period from October, 1983 to September, 1984, there was 462.8 mm of throughfall at the collectors in the white pine grove. The pH was 4.75 for the throughfall compared to 4.78 for the incident precipitation confirming that the white pine canopy had little effect on H^+ concentration. Values for key constituents in the white pine throughfall are shown in Tables 8 and 9. These values show that there is marked enrichment in throughfall compared to incident precipitation for all of the constituents except for ammonium and nitrate. The enrichment is most pronounced for calcium, magnesium, potassium and aluminum, suggesting that throughfall is a key pathway for cation cycling. There appears to be conservation or net assimilation of nitrogen compounds in the incident precipitation by the canopy.

Comments

See comments for 3.1 regarding pooling of samples.

In the trembling aspen grove the canopy throughfall collector receives throughfall through a trembling aspen and mountain maple (Acer spicatum) canopy. For this reason a separate shrub throughfall collector was not installed. The data for the trembling aspen grove will have to be analysed differently from the other canopy data. No shrub throughfall collector was installed in the black spruce grove because of lack of understory. Shrub throughfall data are extremely limited as yet because the collectors were only recently installed.

A potential problem with the throughfall measurements is relating the data to canopy size. There are no data on canopy parameters such as width and depth of canopy for the sampled trees or the watershed. Without such data it may prove difficult to use the grove data to extrapolate to estimates for the

entire watershed.

3.3 Stemflow

Purpose

Leaves and branches intercept a high percentage of incident precipitation in forested regions and a significant part of this intercepted precipitation is channeled down by the branches to the main stem of the plant and reaches the soil as stemflow. It is well established that precipitation undergoes chemical changes as it passes through the vegetation, losing some nutrients that are taken up by the plants and gaining others that are leached from the biomass interfaces. Measurement of precipitation stemflow is necessary to qualify and quantify these changes to determine the nutrient budget within the watershed.

Field Activities

Precipitation stemflow collectors are located on each of the sample trees in each grove. A collector consists of a piece of split plastic tubing stapled and sealed to the tree trunk leading to a sealed 26 litre garbage can.

The collectors were installed in the four original groves in the summer of 1983 and monitoring began then. The white birch grove was relocated in April 1984. In the spring of 1985, collectors were installed and monitoring began in the black spruce and jack pine groves.

Volume and pH for each collector are measured in the field.

Laboratory Analysis

Two hundred and ninety-nine stemflow samples were collected and sent for analysis to the MOE laboratory from July 25, 1983 to January 27, 1986. The stemflow samples are pooled for each grove. Prior to June 17, 1985 the

samples were pooled on an equal volume basis. From June 17, 1985 to September 5, 1985 selected duplicate samples, proportional and equal volume, were collected and sent. Since September 18, 1985, all samples were pooled on a proportional basis. By January 27, 1986 all of the samples had been analysed. Tests done were CAUR, MGUR, NAUR, KKUR, pH, ACDG, CLIDUR, NN03UR, SS04UR, PP04FR, NNHTFR, FEUT, MNUT, ALUT AND ZNUT.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Other data are on file.

Data Analysis

An analysis of comparative data for stemflow, throughfall and incident precipitation for 16 precipitation events from July 25, 1983 to September 17, 1983 was done. Compared to incident rainfall pH the average pH of stemflow for aspen was higher while stemflow pH in white birch and balsam fir showed little change. In contrast white pine stemflow was much more acidic than incident rain.

A comparison of white pine throughfall and stemflow was produced during the summer of 1985 based on data from October, 1983 to September, 1984. It confirmed that white pine stemflow was more acidic (pH 4.41) than incident rainfall (pH 4.8) or white pine throughfall (pH 4.75). Ammonium and nitrate concentrations were much lower than incident and throughfall concentrations suggesting that nitrogen compounds were absorbed, possibly by the epiphytic flora (Table 9). It should be noted, however that the stemflow data are not strictly comparable to those for incident precipitation and throughfall because the latter include data for snow whereas only rain is measured in stemflow.

Comments

See comments for 3.2 regarding canopy parameters and for 3.1 regarding bulk versus proportional pooling.

If further analyses confirm that pooling differences have caused significant variations in the data, much of the stemflow data may be limited in comparability with data from other biogeochemical study sites in Ontario.

Chapter 4

FIXED INTERVAL MONITORING

4.0 FIXED INTERVAL MONITORING

4.1 Incident Precipitation

Purpose

As stated in 3.1, incident precipitation is the key outside input to the watershed. Cumulative precipitation is measured on a fixed interval basis year-round by the Sangamo sampler which also provides data that are comparable to the rest of the APIOS deposition network.

Field Activities

The Sangamo collector was installed on the instrument platform during the summer of 1983 when monitoring began. The Sangamo collector monitors wet deposition only. Samples are taken every 28 days for chemical analysis. A Nipher storage rain gauge and a standard rain gauge are monitored during visits to the instrument platform. The Nipher gauge is monitored on the same 28 day basis as the Sangamo collector.

Laboratory Analyses

Thirty Sangamo incident precipitation cumulative samples were collected and sent to the MOE lab from August 16, 1983 to January 27, 1986. Tests were done for VOL, COND25, CAUR, MGUR, NAUR, KKUR, PH, ACDT, ACDG, CLIDUR, NNO3UR, SS04UR, PPUT, NNTKUR, NNHTUR, CUPDT, CUPBT, NIPDT, PBPDT, PBPBT, ZNPBT, CDPDT, FEPDT, FEPBT, MNPDT, ALPDT, ALPBT, VVPDT, and VOLDDA. All of these analyses have been completed.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some of the analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Data Analysis

No data analysis has been done to date.

Comments

Freezing rain has occasionally caused problems by immobilizing the arm of the collector.

4.2 Snowfall

Purpose

Snowfall measurement and analysis is the continuation of precipitation data gathering into the winter months when precipitation can no longer be measured using the event rain samplers.

Field Activities

Snowfall collectors consist of 64.4 litre garbage cans with a 0.153 m² collection area and lined with polyethylene bags located near the instrument platform and in each sampling grove and two Nipher-shielded snow gauges near the instrument platform.

The garbage can samplers were first used in the winter of 1983-1984. Three samplers were located in the clearing near the instrument platform and one on the opposite side from the canopy throughfall collector at each tree monitored in the white pine, balsam fir, trembling aspen and new white birch groves. Samplers at the jack pine and black spruce groves were first used during the winter of 1984-1985 and 1985-1986 respectively. Samplers were also used at the old white birch grove during the winter of 1983-1984.

Samples are collected on a weekly basis, allowed to melt in the utility trailer, measured for volume and then transported to the Lakehead Laboratory.

The Nipher gauges were installed and started operating in the winter of 1984-1985. One is used to measure weekly snowfall while the other is used for cumulative snowfall.

Laboratory Analyses

Forty-eight samples from the clearing samplers and 239 samples from the groves were collected and sent to the MOE laboratory from November 25, 1983 to

January 27, 1986. Tests done on samples from both clearing and grove collectors were CAUR, MGUR, NAUR, KKUR, PH, ACDG, CLIDUR, NNO3UR, SS04UR, PPO4FR, NNHTFR, FEUT, MNUT, ALUT and ZNUT.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some of the laboratory analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Some data have been tabulated (Tables 6 and 7).

Data Analysis

Snowfall data were used in comparing white pine throughfall and incident precipitation (see 3.1 and 3.2; Tables 8 and 9).

Comments

It is difficult to correlate the snow throughfall in the groves with the incident snowfall because of the snow that remains suspended in the canopy. Snow accumulation on the Nipher gauges, despite regular clearing, may cause inaccurate measurements. The Aerochem Metric should also be collecting snow but the sensor is not sensitive enough for reliable sampling in the winter months.

4.3 Snowpack

Purpose

Data on snowpack depth can be of use, when compared with snowfall data, in establishing rates of loss of snow due to melting and sublimation. This can be of value when establishing the overall watershed water budget. Data on snowpack chemistry are particularly important in relation to data on spring runoff chemistry, of vital concern to freshwater systems.

Field Activities

Snow depth is measured at least weekly at fixed metre sticks in the tree groves (2 per grove) and in the clearing near the instrument platform (2). Snowpack composite columns are taken in the clearing at the end of the winter. Field pH and conductivity measurements are done. In addition a comparison of snow pH at 2 sites was done in the winter of 1982-1983.

Laboratory Analyses

To January 27, 1986 one column was sent for analysis to the MOE laboratory.

Data Storage and Management

The laboratory analysis is on SIS and on file.

Other data are on file.

Data Analysis

A short report was produced on the results of the 1982-1983 pH comparison.

4.4 Dry Deposition

Purpose

Atmospheric loadings of dry material onto the watershed are potentially significant in the overall nutrient balance. By using the same type of sampler as is used in the APIOS deposition network the watershed can be more easily compared to other deposition network sites.

Field Activities

Atmospheric loading is measured with a standard low-volume air sampler. Filters are removed for analysis and replaced every 28 days. The sampler was installed on the instrument platform during the summer of 1983 and dry deposition has been monitored since then.

Laboratory Analyses

Thirty-one low volume air samples were collected from August 16, 1983 to January 27, 1986. Analyses have been received for 26 of these samples as of January 27, 1986. Tests were done for CAUR, MGUR, ALUR, CDUR, CUUR, FEUR, NMUR, NIUR, PBUR, VVUR, ZNUR, NAUR, KKUR, CLIDUR, NNO3UR, SS04UR, NNRICF and SS02FR.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some of the laboratory analyses are also on the Lakehead Rainbow computer.

Data Analysis

No data analysis has been done to date.

4.5 Litterfall

Purpose

There is a continuous loss of organic material from the living plants to the forest floor in the form of leaves, needles, twigs, branches, bark and cones. This litterfall plays a significant part in the overall nutrient cycling as the litterfall decomposes and becomes part of the soil complex. It is therefore necessary to quantify and qualify this nutrient flow to determine the watershed budget.

Field Activities

In the summer of 1983 litterfall collectors were installed in the white pine, balsam fir, trembling aspen and old white birch groves. In April, 1984, the white birch grove was relocated and sampling began at the new grove. In the spring of 1985 litterfall samplers were installed in the jack pine and black spruce groves.

Two samplers were originally located in each grove. They are positioned one-half of the distance between the trunk and the drip line of the largest and smallest dbh trees monitored for stemflow. In the fall of 1985, an additional sampler was added to each grove to increase sample size. The samplers are square, use 1 mm mesh, and have a collection surface area of 0.5 m². Litterfall samples are collected at specified times (6 samples a year).

Laboratory Analyses

The samples from each collector are separated into leaves, twigs and other material and fresh weights are taken. They are then oven dried, weighed and ground to 1 mm in a mill.

One hundred litterfall samples were collected and sent to the MOE laboratory from November 30, 1983 to January 27, 1986. They were tested for FEUT, MNUT, PPUT, NNTKUR, ALUT, CAUT, CDUT, CLUT, CUUT, KKUT, MGUT, MOUT, NAUT, NIUT, PBUT, SSUT and ZNUT. Analyses have been received for 65 of the samples as of January 27, 1986.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some laboratory analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Data Analysis

Analyses of litterfall oven dry weights for white pine, balsam fir, trembling aspen and white birch samples collected from August to October, 1983 were done. Foliage comprised the bulk of the litterfall. The dry weights of foliage from white birch, trembling aspen and white pine were similar and were much greater than that from balsam fir. Twig dry weight was greatest in white birch litterfall, less for aspen and very little for white pine and balsam fir. Most litterfall occurred in October, as expected.

Comments

There is some uncertainty regarding the effects of the litterfall collector on normal animal activities. Reduced foraging may increase or decrease the amount of food materials in the collector over adjacent areas of the forest floor.

4.6 Litter Decomposition

Purpose

Litter on the forest floor decomposes and either becomes part of the soil complex or washes away with runoff. A litter decomposition study is a logical follow-up to the litterfall study and is equally necessary in determining the overall nutrient budget.

Field Activities

In the fall of 1984, 1 mm mesh bags were placed adjacent to the white pine, balsam fir, trembling aspen and new white birch groves containing oven dried leaf and twig litter of the appropriate overstory species. In the fall of 1985, leaf and twig litter bags were placed in the black spruce grove. At each monitoring site, 50 leaf bags and 25 twig bags were secured to the ground after the existing litter was removed. Maximum-minimum thermometers and soil moisture tensiometers were installed in the litter. In addition to bags collected at the start of the monitoring to serve as a control, leaf samples are scheduled for collection in the early spring, mid-summer and late autumn of 1985, 1986 and 1987. Twig samples are collected once a year only. Readings from the thermometers and tensiometers are made on an event basis or, if no rain occurs, on at least a weekly basis.

Laboratory Analyses

After the litter bags are collected, their contents are removed, oven dried, weighed and ground to 1 mm size in a mill. Samples are then sent to the MOE laboratory for analyses. One hundred and twenty-nine litter samples were collected and sent from November 8, 1984 to January 27, 1986. They were tested for FEUT, MNUT, PPUT, NNTKUR, ALUT, CAUT, CDUT, CLUT, CUUT, KKUT, MGUT, MOUT, NAUT, NIUT, PBUT, SSUT and ZNUT. Analyses have been received for 79 of the samples as of January 27, 1986.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Other data are on file.

Data Analysis

No data analysis has yet been completed.

Comments

The presence of moss on the forest floor of the black spruce grove necessitated special procedures.

The decomposition plots are sensitive to disturbance and flagging has been used to reduce any chance of accidental trampling.

The use of the 1 mm mesh bags represents a compromise between the need to keep the contents in one place for easy measurement and the need to allow normal decomposition activities to proceed.

4.7 Streamwater

Purpose

Streamwater flowing out of the watershed is the main source of nutrient loss from the watershed. Data on streamflow and stream chemistry are essential to preparing a water and nutrient budget for the watershed. The chemistry of the streamwater also has impacts on aquatic systems downstream, especially during spring runoff.

Field Activities

The streamwater measurements are taken at the weir stilling well. Streamflow measurements began in February, 1984 after the weir was operational, although streamwater sampling for chemical analyses began in September, 1983.

Weekly measurements are made of flow rate (using a fixed staff gauge), pH, water temperature and conductivity. Water samples for chemical analyses are taken at the same time from a point 20 m above the weir enclosure. During spring runoff measurements and sampling are conducted daily. Monitoring of streamwater continues year-round.

Laboratory Analyses

One hundred and thirty-three streamwater samples were collected and sent to the MOE laboratory from September 20, 1983 to January 27, 1986. Tests were done for ALUT, ZNUT, CAUR, MGUR, NAUR, KKUR, PH, ACDG, CLIDUR, NNO3UR, SS04UR, FEUT, MNUT, PP04FR and NNHTFR. All of these analyses have been completed.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Some laboratory analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Some tabulation of data has been done (Tables 10 to 12).

Data Analysis

No data analysis has been done to date.

Comments

Although the weir enclosure is heated, freezing can occur if the temperature remains below -30°C for a prolonged period.

TABLE 10
WEIR WATER DISCHARGE AND pH
(APRIL 1985 - NOVEMBER 1985)

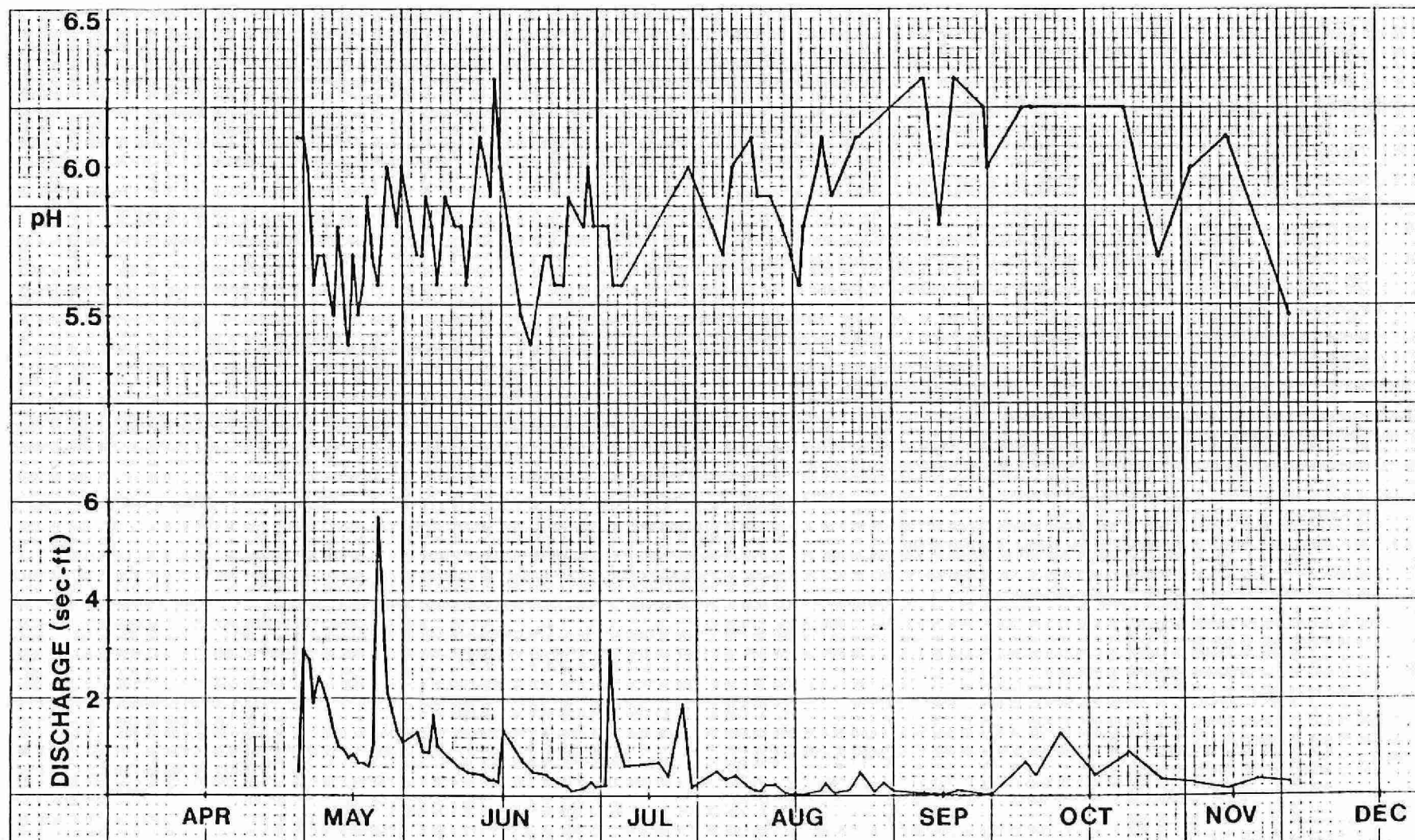


TABLE II

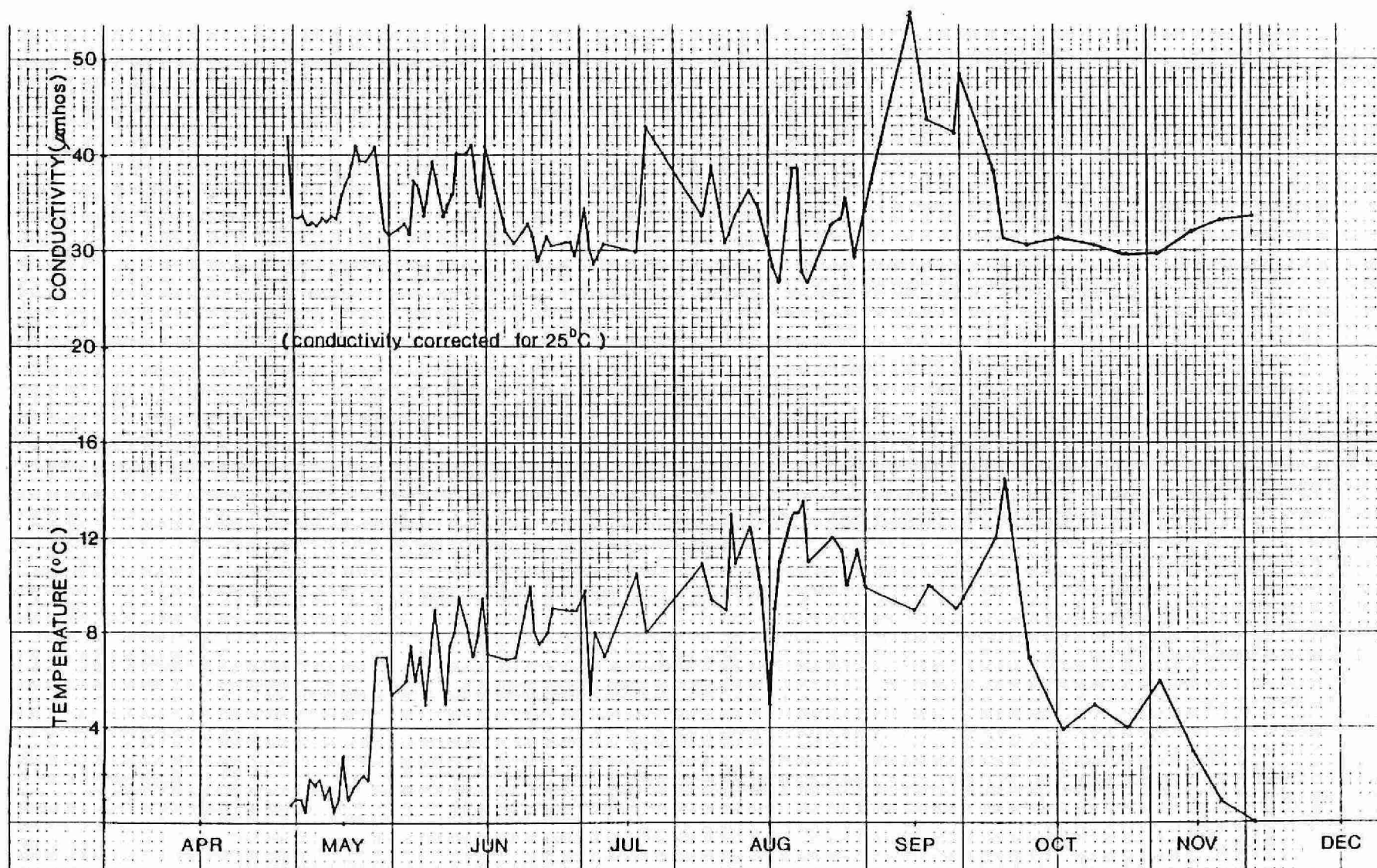
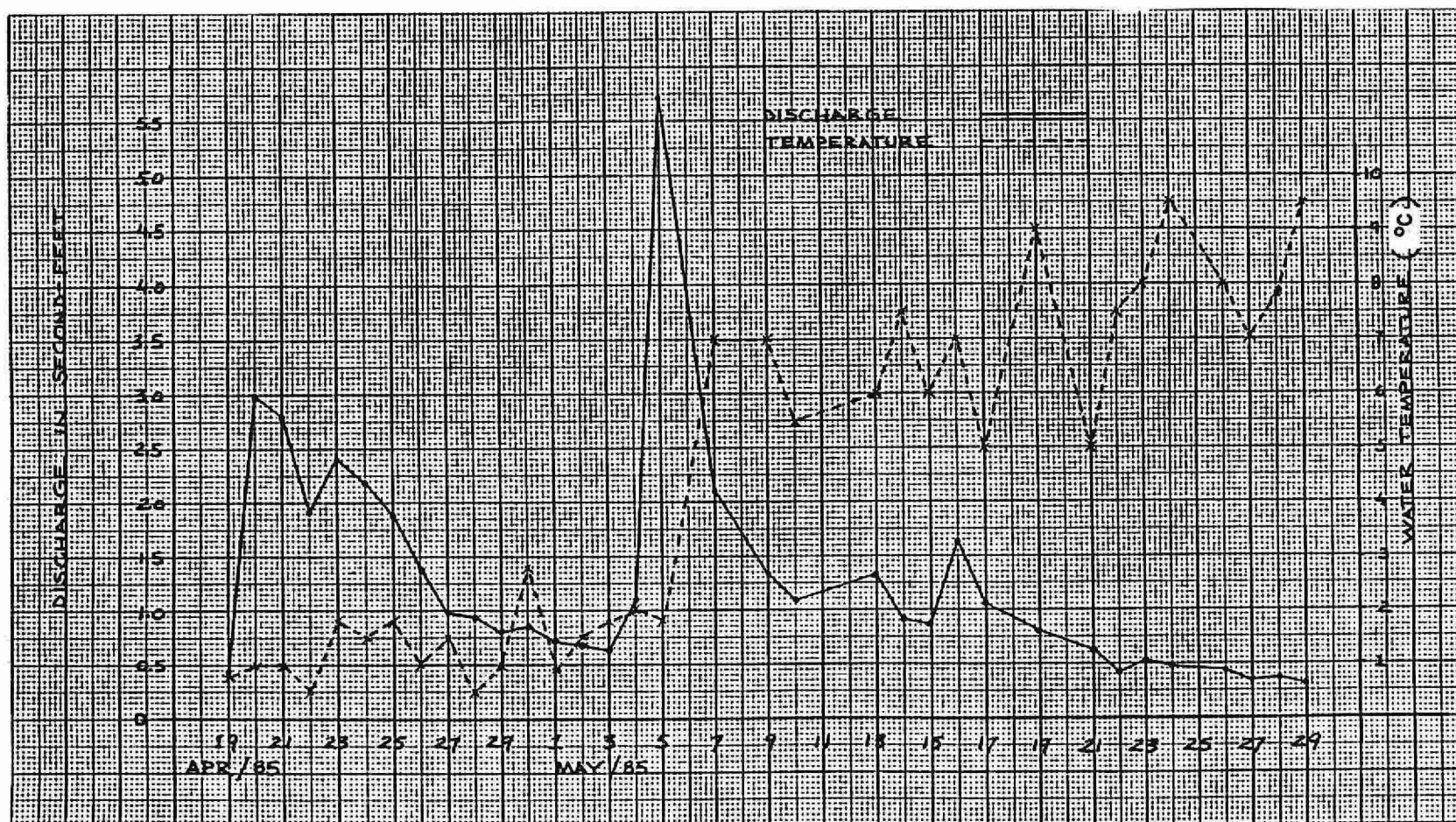
WEIR WATER TEMPERATURE AND CONDUCTIVITY
(APRIL 1985 - NOVEMBER 1985)

FIGURE 12

SPRING RUNOFF WEIR WATER DISCHARGE AND TEMPERATURE (APRIL 1985 - MAY 1985)



4.8 Groundwater

Purpose

It has been speculated that acidic precipitation could affect shallow groundwater. Groundwater is also assumed to have the potential to affect the surface water leaving the watershed and therefore downstream aquatic systems. Measurement of groundwater levels and groundwater chemistry throughout the watershed is therefore necessary. These measurements can also be used with the weir streamflow data to help estimate a runoff and total water and nutrient budget for the watershed.

Field Activities

During May, 1984, a field survey of the shallow water table and seepage areas was carried out in conjunction with MOE staff (see 2.4). As a result of this survey, 24 possible monitoring sites were identified.

A hydrological sampling system (see Figure 27) consisting of an observation well and 18 stand-pipes was installed and monitoring was begun in the fall of 1984.

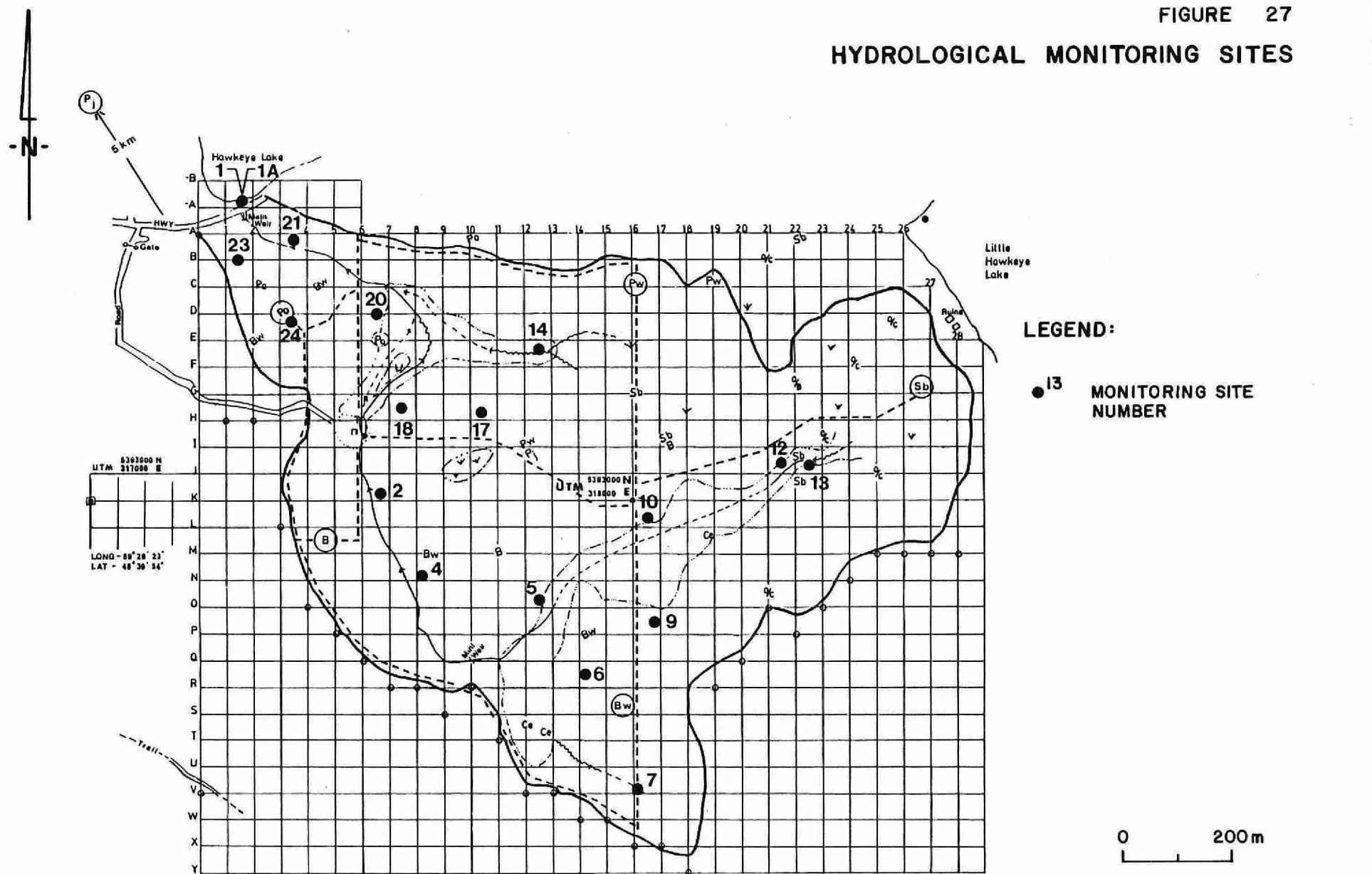
Water level is measured and samples for analysis are taken monthly. Samples are also taken on a monthly basis at the stream and at Hawkeye Lake. At time of sampling field measurements of pH, conductivity and soil and water temperature are also taken.

Laboratory Analyses

Seventy-seven groundwater samples were collected and sent to the MOE laboratory from May 29, 1985 to January 27, 1986. Tests done were ALUT, ZNUT, CAUR, MGUR, NAUR, KKUR, PH, ACDG, CLIDUR, NNO3UR, SS04UR, FEUT, MNUT, PP04FR and NNHTFR. All of these analyses have been completed.

FIGURE 27

HYDROLOGICAL MONITORING SITES



LEGEND:

- 13 MONITORING SITE NUMBER

Data Storage and Management

Laboratory analyses are on SIS and on file.

Other data are on file.

Some tabulation of groundwater data has been done (see Tables 13 and 14).

Data Analysis

No data analysis has been done to date.

Comments

It may be necessary to relocate standpipes 5 and 10 because they are drawing in swamp water. An additional standpipe may be desirable around map coordinates Q10.

Monitoring of deep groundwater may be useful but setting up a deep groundwater monitoring system would be expensive.

TABLE 13

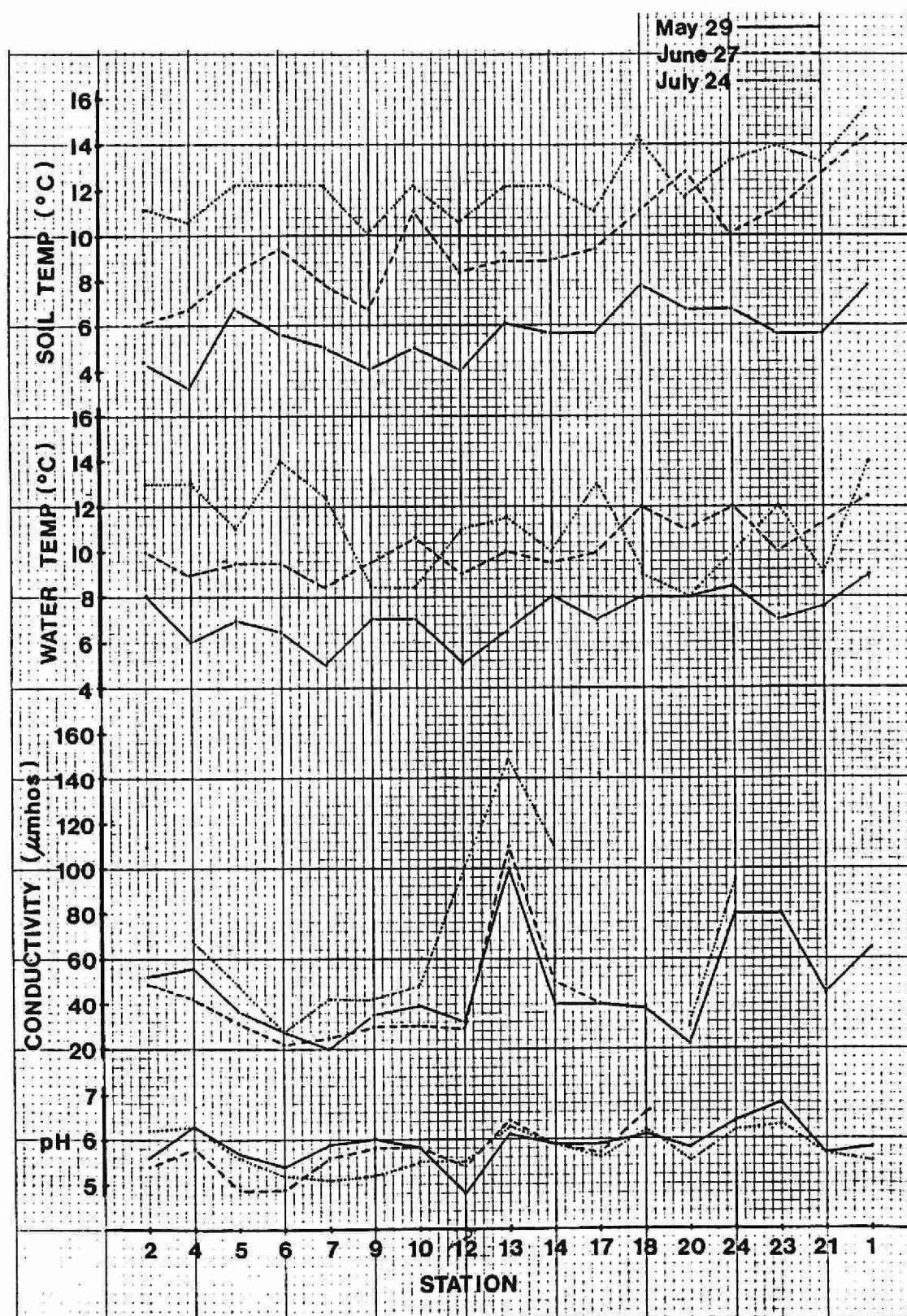
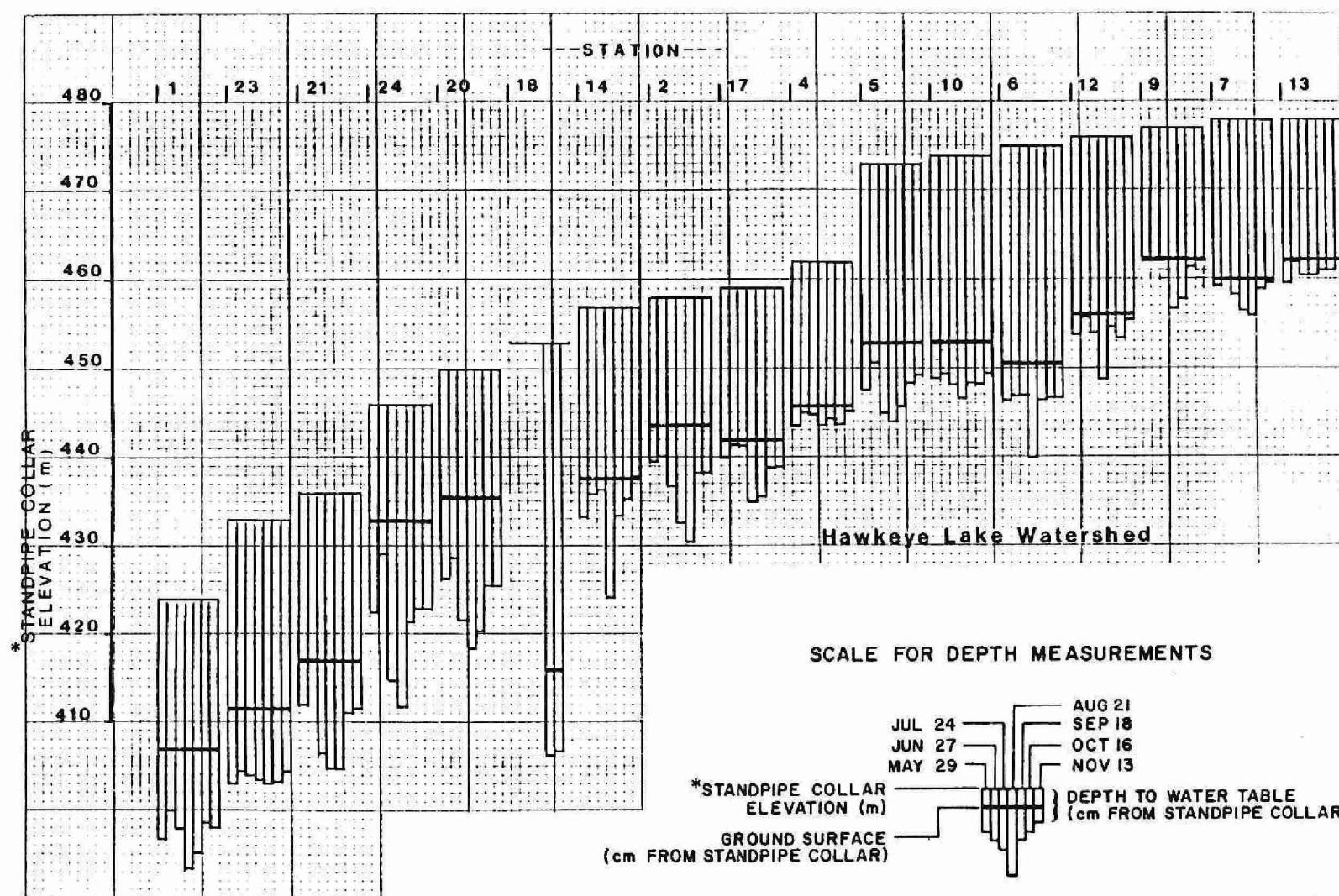
HYDROLOGICAL MONITORING
(MAY 1985 - JULY 1985)

FIGURE 14

SEASONAL WATER TABLE FLUCTUATION (MAY 1985 - NOVEMBER 1985)



4.9 Lysimeter Leachate

Purpose

It is thought acidic precipitation may change the chemical properties of forest soils. On the other hand, it is also assumed that the forest soils may change the chemical properties of the water coming through the forest soil as incident precipitation, throughfall or stemflow. Monitoring of soil leachate is therefore a key part of establishing the nutrient budget in the watershed.

Field Activities

Two types of lysimeters have been installed at the tree groves. Tension lysimeters consist of ceramic discs to which vacuum is applied to extract a leachate sample. In the zero-tension lysimeters, no vacuum is applied to extract the leachate which drains into a collecting bottle.

Tension lysimeters were installed in the fall of 1983 in the balsam fir, white pine, trembling aspen and new white birch groves. Monitoring of these groves began in the spring of 1984. One tension lysimeter set is installed in each grove, under a representative tree that is not being monitored for precipitation. Three tension lysimeters are installed at each location: one in the middle of the A horizon, one in the middle of the B horizon and one approximately 15 cm below the upper boundary of the C horizon.

The tension lysimeter leachate samples are withdrawn using a constant vacuum pump on a weekly basis if water is available. In practice, lack of available leachate except at spring runoff and lack of time for monitoring has resulted in no samples being collected from the tension lysimeter from their original installation to January 27, 1986.

To remedy the lack of leachate and reduce the time required for sampling, zero-tension lysimeters were installed at the white pine, balsam fir, trembling aspen, white birch and black spruce groves in the fall of 1985. At

each grove, except the black spruce, two lysimeters were installed under the organic layer, in the middle of the B horizon and 15 cm into the C horizon. High water levels at the black spruce grove allowed only the two organic layer lysimeters to be installed.

Laboratory Analyses

No leachate was collected from the tension lysimeters to allow for laboratory analyses.

As of January 27, 1986 no zero tension lysimeter leachate had yet been submitted for analysis.

Date Storage and Management

Not applicable at this stage.

Data Analysis

Not applicable at this stage.

Comments

A lot more time is needed to collect lysimeter leachate data to compare with other watershed data.

4.10 Temperature

Purpose

Temperature is a basic variable in the environment that indirectly affects the overall nutrient and water cycles. It is a particularly important factor affecting evaporation and evapotranspiration. It also is a basic determinant in rates of chemical reactions.

Field Activities

A maximum-minimum thermometer was installed in a Stevenson screen near the instrument platform to monitor air temperature. Temperature readings from this thermometer have been recorded on at least a weekly basis since the summer of 1983.

In the summer of 1985, remote reading maximum-minimum thermometers were installed just below the litter layer at each decomposition plot at the white pine, balsam fir, trembling aspen and white birch grove. They are monitored on an event or at least weekly basis. Temperature measurements are also made in the course of groundwater and streamwater sampling and in the clearing during event sampling.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on file.

Data Analysis

Some data from the clearing thermometer have been tabulated (see Tables 15 and 16).

FIGURE 15

MAXIMUM - MINIMUM TEMPERATURES
(OCTOBER 1983 - SEPTEMBER 1984)

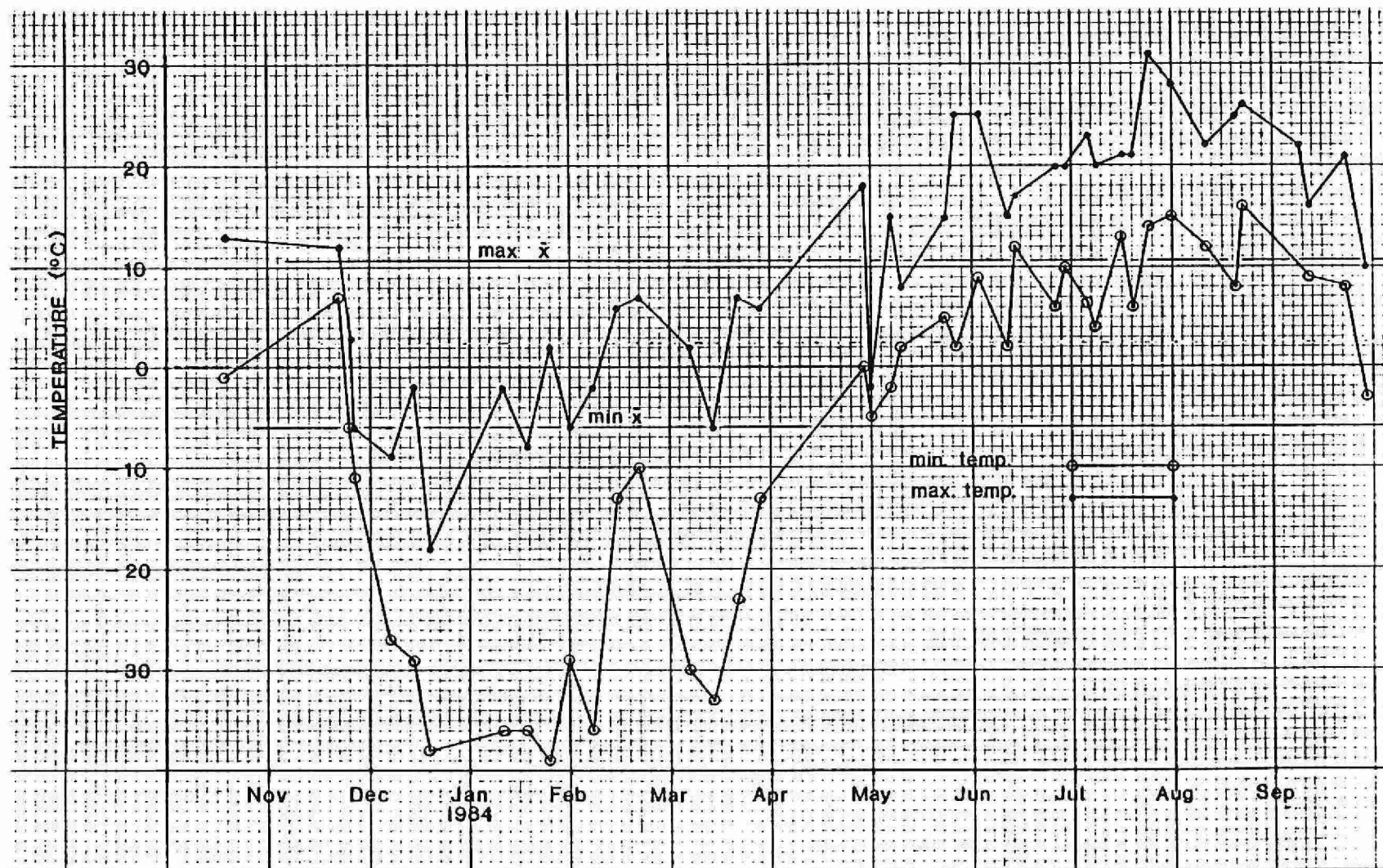
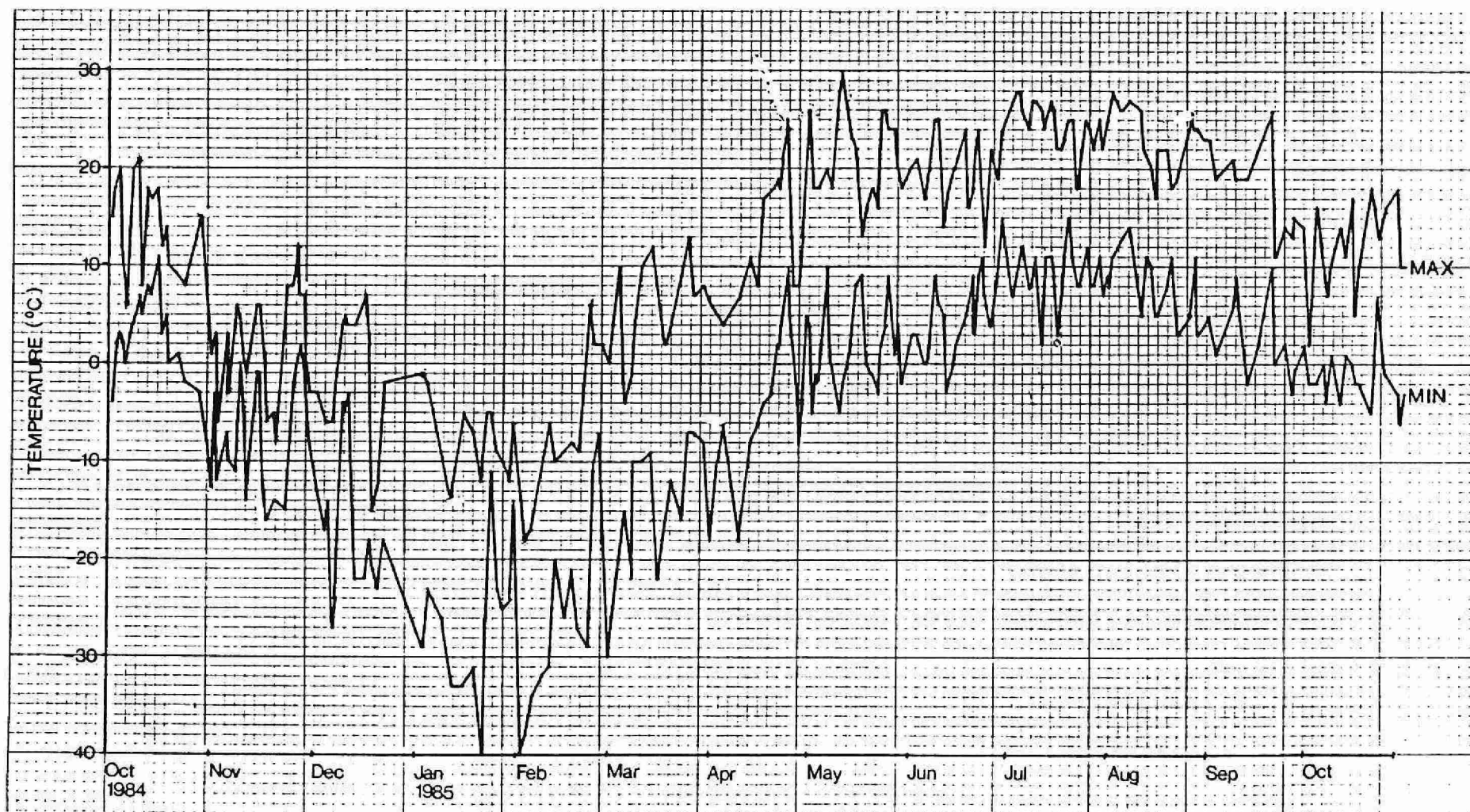


TABLE 16

**MAXIMUM - MINIMUM TEMPERATURES
(OCTOBER 1984 - OCTOBER 1985)**

4.11 Evaporation and Evapotranspiration

Purpose

The estimation of evaporation and evapotranspiration is an essential element in the calculation of the overall watershed water budget.

Field Activities

No field activities have been undertaken to date.

Laboratory Analyses

Not applicable.

Data Storage and Management

No data was collected for Hawkeye Lake Biogeochemical Study Site.

Data Analysis

Some estimations of evaporation and evapotranspiration could be made based on information on temperature and other variables measured at Hawkeye Lake, but that has not yet been done.

Comments

An evaporation pan such as the one used at High Falls would be a useful addition to the Hawkeye Lake monitoring systems and has been included in recommendations for future programmes.

4.12 Accelerated Soil Leaching Experiment

Purpose

This experiment was designed to measure the effects of simulated acid rain at different acidity levels on a known common soil profile. The data can also be used for a comparison with soil baseline information collected in areas with different acid loadings and aid in the derivation of a soil sensitivity rating.

Field Activities

In August, 1983, fifteen intact 100 cm long soil columns were removed from an area at the Hawkeye Lake biogeochemical study site and placed in open top PVC tubes.

Laboratory Analyses

The fifteen columns in the laboratory were subjected to five different acid loadings ranging from pH 2.0 to 5.5 applied at a rate equivalent to 2 years of average precipitation per year of experiment. Leachate was collected weekly and bulked monthly for each column. Leachate subsamples were sent to the MOE laboratory for the following analyses: pH, CLIDUR, SS04UR, NNHTFR, FEUT, MNUT, ALUT, ZNUT, CAUR, MGUR, NAUR and KKUR. Five hundred and thirty-one samples were sent to the MOE laboratory from August, 1983 to January 27, 1986 and all but 35 have been analysed as of January 27, 1986.

Data Storage and Management

Laboratory analyses are on SIS and on file.

Most of the laboratory analyses are also on the Lakehead Rainbow computer.

Other data are on file.

Data Analysis

A status report on the Phase I results was produced in November, 1985. Data evaluation is available for pH and sulphate ions and information on nitrate and aluminum has been reviewed but not yet summarized.

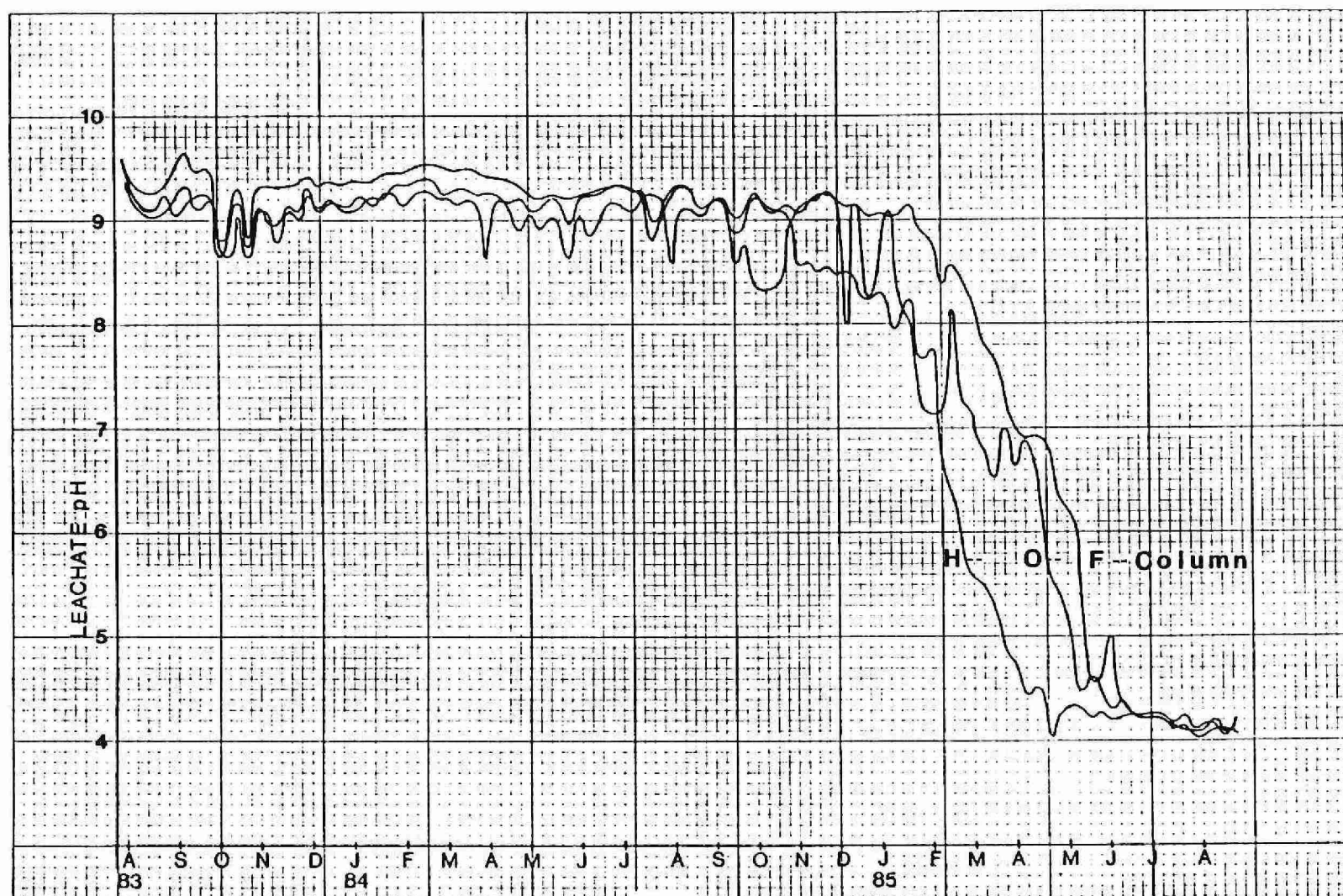
Initial leachate pH was basic with a pH above 9 for all levels of acidification. This increase in pH is thought to be due to the solubilization of mineral complexes which act to buffer the soil porewater. This reaction and ion exchange between the soil and liquid phases should result in an increased concentration of cations such as Ca, Mg, K, Na and associated anions. When the soil column buffering and absorption capacity is exhausted, the levels of ions such as Ca, Mg, K and Na found in the leachate would decrease and the concentration of H ions increase. After about a year and a half, the columns with pH 2.0 loading showed a marked decrease in leachate pH (Table 17). It was expected that a similar "acid breakthrough" would have occurred in the pH 2.5 column within the next year.

Comments

The November, 1985 report contained proposals for future work. It recommended that Phase I data be fully evaluated and then that a Phase II be initiated. Various options were given for pursuing the accelerated leaching experiment. The Hawkeye accelerated soil leaching column was the only one still going on at any of the biogeochemical sites and was therefore of high potential value. The Biogeochemical Working Group however decided that the project should be terminated. Accordingly the columns were dismantled in February, 1986. Some additional work on the physical state of the soil columns is underway.

TABLE 17

ACCELERATED LEACHING EXPERIMENT
LEACHATE pH OF COLUMN TREATED WITH pH 2.0 SOLUTION



4.13 Open Column Soil Leaching Experiment

Purpose

The objective of this inter-regional study is to determine the long-term (20 years) chemical changes in a soil exposed to different levels of long-range atmospheric pollutants under varying climatic conditions. This information will also supplement the findings of the soil baseline program.

Field Activities

Seventy-two sections of 50 cm long PVC pipe were filled with representative soil samples taken in 1981 from three areas in Ontario (Balls Falls Conservation Area on the Niagara Escarpment, Sorrell Lake at the Abitibi Woodlands Laboratory and the Killarney Experimental Plot). The 72 pipes were then distributed among three regions of the province (Northwestern, Northeastern and Southern) so that each region had at least 8 soil columns of a sandy soil from northwestern Ontario, 8 columns of a clay soil from northeastern Ontario and 8 columns of a silty soil from southern Ontario. The soil columns were stored under refrigeration until they were placed in the field.

In September, 1983, 24 soil columns were installed in the ground at the Hawkeye Lake biogeochemical site.

Laboratory Analysis

At intervals of 5, 10, 15, and 20 years from the start of the study, duplicate columns from each of the three soil types will be removed and samples from the A and B horizons prepared for chemical analyses. No analyses have been done to date.

Data Storage and Management

Characteristics of the soils are given in Open-top Soil Column Study (MOE, 1983).

Data Analysis

None have been done to date.

Comments

Serious criticisms have been made of the way the soil samples were extracted. The horizons for each soil type were thoroughly mixed before being placed in the tubes. This had the effect of destroying the soil structure, probably a key characteristic of any soil. It was suggested at the 11 July, 1985 TEWG B meeting, that the experiments be removed, however the group decided that the columns be left in place for the time being. The current Hawkeye Lake contractors agree that there are very serious problems with the experimental design of the experiment and that its value is questionable.

Chapter 5

CONTINUOUS MONITORING

5.0 CONTINUOUS MONITORING

5.1 Air Quality

Purpose

A major purpose of the biogeochemical study is to document cycling under different acid loading conditions. Because this loading may occur in the form of gaseous deposition, measurement of air quality at each site is therefore carried out. Ozone, a pollutant involved in long-range transport, is also monitored at each study area.

Field Activities

The instrument trailer housing the air quality monitoring equipment was installed during the spring of 1983 and became fully operational by the summer of 1983. The monitors consist of a pulsed fluorescent SO_2 analyzer, a U.V. photometric O_3 analyzer and a chemiluminescent NO_x analyzer.

All repairs and calibration of the monitors are the responsibility of the MOE and are often handled directly by MOE staff.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on a different MOE database than the other data: The Air Quality Information System (AQIS).

Data Analysis

No data analysis has been done to date.

Comments

Periodic breakdowns and repairs have caused some data gaps.

5.2 Wind Speed and Direction

Purpose

Wind direction could provide useful information, when correlated with air quality data, on the sources of air pollutants at Hawkeye Lake. Wind speed may be an important factor in evaporation and evapotranspiration rates.

Field Activities

A 22 m meteorological tower was erected in the summer of 1983 in the clearing adjacent to the instrument trailer. A Skyvane 1 wind sensor was installed on the tower and continuous monitoring began during the summer of 1983.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on AQUIS.

Data Analysis

No data analysis has been done to date.

Comments

There have been frequent problems with the wind monitoring equipment so that

there are significant gaps in the data record. Lightning striking the tower has been a particular problem as it has disabled the equipment causing delays as new equipment is ordered and installed or equipment is repaired.

To be able to determine wind direction for long range pollutant transport a higher tower, at least 17 m above the forest canopy top, is needed. Lower measurements are likely to be in the boundary layer and may not reflect the direction of movement of long range pollutants.

5.3 Temperature and Relative Humidity

Purpose

Temperature and relative humidity are basic variables in the environment that indirectly affect the overall nutrient and water cycles. They are particularly important factors affecting evaporation and evapotranspiration.

Field Activities

A recording hygrothermograph was installed in a Stevenson screen near the instrument platform in 1984. The recorder is used only during the summer because the instrument does not function at temperatures below freezing.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on file.

Data Analysis

No data analysis has been done to date.

Comments

The recorder has had frequent problems so that the record has many gaps.

It may be useful to install a recording thermometer to obtain winter temperatures on a continuous basis.

5.4 Stream Flowrate

Purpose

The amount of water leaving the watershed is one of the key quantities that has to be determined to calculate a water budget and a nutrient budget for the watershed.

Field Activities

Construction of a compound weir with a 90° V notch was completed in the summer of 1983. The weir is calibrated to handle flow from 0 to 2.5 ft/sec. The installation includes a weir enclosure to protect equipment, a stilling well and a continuous water level recorder. Electric service to the weir shelter was provided by early 1984 allowing monitoring to continue during the winter months.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on file.

Data Analysis

Some data have been tabulated.

Comments

Despite the heated weir enclosure, the water can freeze if temperatures remain below -30°C for a prolonged period.

5.5 Groundwater Level

Purpose

Continuous monitoring of the groundwater level can give useful information on water movements in the watershed, especially when correlated with precipitation data.

Field Activities

An observation well, located at map coordinates H7 (see Figure 27), was equipped with a Stevens A35 recorder to monitor groundwater level. Monitoring began in the fall of 1984.

Laboratory Analyses

Not applicable.

Data Storage and Management

Data are on file.

Data Analysis

No data analysis has been done to date.

Comments

There have been problems with the recorder timing mechanism which has proved erratic. It has been fixed several times.

Chapter 6

CONCLUSIONS

6.0 CONCLUSIONS

The Hawkeye Lake Biogeochemical Study Site is well located. The watershed is well defined and physically drains through one pathway to Hawkeye Lake. It is conveniently close to Thunder Bay and to a good road. The watershed is of a manageable size. There is good access to the weir, instrument platform and trailers. The watershed has acid sensitive soils and typical boreal forest vegetation. The location of the site in a low acid loading region means that it has a valuable role to play as a control site. Should increased acid loading become more widespread in Ontario in the future, data currently gathered here may prove to be irreplaceable.

The site was developed with a great deal of care. Impacts to the watershed were minimized by reducing the amount of vegetation cutting and keeping all trails narrow. At each monitoring grove elevated walkways and work tables ensure that vegetation trampling and soil compaction do not influence the monitoring results. No motorized vehicles are used on site to reduce physical impacts and possible chemical contamination.

Monitoring at Hawkeye Lake has also been carried out with care and valuable data have been gathered. However, not all monitoring programmes have been in place for the same amount of time. For example, monitoring for soil lysimeter leachate and at the black spruce and jack pine groves only started in 1985.

Until 1985, data storage and management has received little emphasis compared to the field programme because of the need to get the complete field programme to an operational status. Data handling has increased and improved considerably during the past year. A quality assurance programme has been implemented to check the data on SIS and a direct hookup between the SIS data base and SENES computers has been successfully used for data analysis of SIS files.

Data analysis, like data storage and management, has improved and expanded during this last year with the production of several reports.

The once only studies should be completed as soon as possible. Most of the field work for these is already done but analysis remains incomplete. These studies are essential to determine such basic items as soil mass and biomass. If upon analyzing the data gathered it is found that there are gaps, these should be filled.

Consideration should be given to starting areal monitoring as is being done at the southern Ontario sites for some canopy-related parameters like throughfall. Data from areal monitoring would allow better extrapolation especially of stemflow and throughfall data to the watershed as a whole. The process by which one converts non-areal grove data to the watershed is still an uncertain one. Areal monitoring would also generate data currently lacking for a mixed forest situation. If areal monitoring is not approved then a mixed grove should be considered as an alternative to provide a relationship between species and areal measurements.

In summary, the Hawkeye Lake watershed is a well located and carefully developed biogeochemical site of great importance as a control site for the Biogeochemical, Terrestrial and possibly other programmes. Sampling at this site must continue for several more years to obtain an adequate statistical data base, and probably should include some areal canopy monitoring, to ensure that the data base is complete. The next few years must also see an increase in emphasis in data management and analysis.

APPENDICES

APPENDIX A

SUMMARY OF FIELD AND LABORATORY PROCEDURES AND PRECAUTIONS TAKEN FOR QUALITY ASSURANCE

I. Event Monitoring

1. Preparation

- label and assign numbers to bottles
(26-500 mL and 26-100 mL - if both proportional and equal volume samples are taken, 17-500 mL and 17-100 mL bottles if only proportional samples are taken)
- count out throughfall and stemflow bags
- pack knapsack
time - approx. 1 hour

2. Trembling Aspen (Po), White Pine (Pw), Black Spruce (Sb), White Birch (Bw) and Balsam Fir (B) Groves

Throughfall

- measure throughfall volumes for each tree (5 trees at Po, Bw, Sb, and Pj; 4 trees at Pw; 6 trees at B)
- determine pH of throughfall for each tree
- save some of sample for equal volume sample
- calculate proportional volume for sample
- measure into graduated cylinder
- determine pH of proportional volume sample
- replace bags
- change throughfall funnels every 2 weeks

Stemflow

- measure stemflow volume for each tree
- determine pH of stemflow for each tree

- save some of sample for equal volume sample
- calculate proportional volume for sample
- measure into graduated cylinder
- determine pH of proportional sample
- replace bags

Shrub Throughfall

- measure shrub throughfall volume (2 collectors at each of Pw, Bw and B)
- calculate proportional volume for sample and measure into graduated cylinder
- determine pH for each collector
- determine pH of proportional sample
- clean dirt, leaves, etc. from troughs and manifold, wipe with Kimwipe
- replace bags

Tensiometers

- take readings from tensiometers, one in twig and one in leaf decomposition plot in each of Po, Pw, Bw and B groves
- pump to remove air bubbles

Soil Temperature

- take readings from max-min thermometers (in same plots as tensiometers)

Time approx. 5.5 hours

3. Jack Pine (Pj) Grove

- drive to grove
- determine pH, measure volumes, and take proportional samples for throughfall and stemflow as above

Time approx. 1 hour

4. Clearing

Funnel Collectors (5)

- determine pH and take equal and proportional volume samples following the same procedure as for throughfall collection

Aerochem

- remove bag, measure volume, take sample
- clean lid with methanol
- replace bag

Storage Gauge

- measure and record storage gauge level and temperature

Time 0.75 hour

5. In Trailer

- acidify 100 mL bottles
- record all bottle numbers in record book
- fill out all record sheets (filter 100 mL bottles)

Time 1.50 hours

TOTAL TIME 9.75 hours

6. General Procedures to Follow During Event Sampling to Reduce Variability and to Avoid Errors:

- (a) Wear gloves for each new sample type.
- (b) Do not touch collection surface (even with gloves).
- (c) Rinse graduated cylinders with distilled water between samples.
- (d) Change gloves before putting new sample bags in collectors.

- (e) Double check calculations for proportional volumes.
- (f) Check that sample bottles are clean and not cracked; keep away from fumes.
- (g) Be sure that lids are on sample bottles correctly.
- (h) Check that all bottles are numbered and labelled correctly and coincide with numbers and labels in the record book and field sheets.
- (i) Acidify the correct bottles.
- (j) Refrigerate samples as soon as possible.
- (k) Do not allow samples to freeze. However, if sample does freeze, thaw at room temperature and shake to mix sample.
- (l) When filtering be sure to rinse all equipment with distilled water between samples.
- (m) Pack samples in coolers correctly before transporting them from the trailer to L.U. lab.
- (n) Minimize time when coolers are open in the lab while completing submission forms.
- (o) Replace ice and tape coolers securely before shipping to Toronto lab.
- (p) After changing the bag on the aerochem be sure that the collar retainer is on securely and in the correct position.
- (q) Do not lean over the top of collectors.
- (r) Be sure that all collectors are level.
- (s) All sample bottles should be filled to the brim so that there is no air space in the bottles.
- (t) When preparing throughfall collector funnels for field use:
 - wear gloves
 - after washing funnels with small amount of "Acationox" rinse funnels well
 - secure nitex to bottom of funnel
 - in field wrap neck of funnel with parafilm to provide tight seal between funnel and collector jar.

II. Weekly Monitoring (Tuesdays)

1. Weir

- take pH, conductivity & depth in weir box
- check water level recorder at stilling well
- take stream sample

2. Clearing

- check rain gauge
- record max., min., and present temperature
- check all instruments

(Note: every 10 days recalibrate SO_2 , NO_x , and O_3 monitors)

3. Stilling well at H7

- check water level recorder

4. P_o , P_w , B_w , B Groves

- record tensiometer readings
- record max.-min. soil temps
- take field notes - leaf fall, leaf out, insect attack, etc.

TOTAL TIME 1 DAY

5. General Procedures to Reduce Variability and Avoid Errors

- (a) Check the calibration of pH meter.
- (b) Check the buffer with lab pH meter.
- (c) For the stream sample be sure to hold the bottle at the bottom and at an angle to the flow; when the bottle is almost full hold bottle vertically (to remove air).
- (d) Check the calibration on tensiometers (remove the tensiometer from the field before the ground freezes).
- (e) Reset the max.-min. thermometers after each reading.

- (f) At the stilling wells - check that the floats are free of obstructions.
- (g) Check the calibration of rain gauge (NB graduations are 0.2).
- (h) Check that the rain gauge is level.
- (i) Read bottom of the meniscus.
- (j) Check the scale for each instrument before recording the value.
- (k) Record measurements only to the nearest half of the smallest marked graduation.
- (l) Monitors in the trailer: check filter, lines, input voltages, sample flow, and vacuum.

III. Hydrology Monitoring (every 4 weeks)

1. Preparation

- label and assign numbers to sample bottles (18 stations - 2-500 mL bottles for each station)
- pack pH and conductivity meters, pump, soil thermometer, water level tape
- check gas and oil levels in generator

Time 0.50 hr.

2. At Each Station

- measure distance from top of pipe to ground and top of pipe to water level
- take soil temperature
- pump $\pm$ 250 mL of water for temperature, pH and conductivity measurements
- pump full 2-500 mL bottles $\pm$ 15 min/station and travel time

Time 8 hr

3. At Trailer

- acidify 1 bottle from each station (filter acidified bottles)

Time 2.5 hr

TOTAL TIME 11 hr

4. General Procedures to Reduce Variability and Avoid Errors

- (a) Avoid pumping too fast or letting water flow back from the tubing into the pipe to prevent stirring up the mud at bottom of the standpipe.
- (b) If the groundwater is low there may not be enough water for pH, conductivity measurements, and 2-500 mL bottles. Do not send bottles which are not full (do not want air in bottles).
- (c) To avoid contamination rinse the tubing between sampling sites (before taking the sample let some water from the new site flow through the

tubing to rinse out water from the previous site).

- (d) When using the portable pump keep fumes away from the sample bottles and site.
- (e) Use clean gloves at each site.
- (f) Between sites keep the sampling hose in a clean plastic bag.
- (g) Replace caps on all standpipes.
- (h) Check the calibration of pH meter.
- (i) When filtering, rinse all equipment with distilled water between samples.

IV. Monthly Changeover Procedures

1. Preparation

- pack lo-vol filter

2. Lo-vol

- take time and volume readings
- zero the meter
- unscrew old filter into a Whirl-Pack bag and seal - mark date packed
- screw in new filter
- check vacuum and flow rate gauges

Time 0.25 hr.

3. Sangamo

- remove bag and seal it
- clean collar and hood with methanol and Kimwipes
- replace bag

Time 0.17 hr.

4. General Procedures to Reduce Variability and Avoid Errors

- (a) Check that papers separating the filter papers in the supplies box are not packed with filters in the lo-vol filter pack.
- (b) Avoid touching the filters.
- (c) Keep a plastic bag (Whirl-pak bag) over the filter when it is removed and another bag over the new filter as it is screwed on.
- (d) Store the lo-vol filters in a plastic bag.
- (e) Check that the heat sealer is working properly.
- (f) Check sealed sangamo bags to assure that the seal is tight and the bag doesn't leak.
- (g) Avoid touching the inside of the sample bag.
- (h) Change gloves after removing the old bag and before installing the new bag.

V. Other Monitoring

1. Snow collections in winter (weekly).
2. Litterfall collections (6/year).
3. Litter decomposition: leaf litter bags - 3 collections/year
twig litter bags - 1 collection/year
4. Lysimeters: disc and zero tension (weekly).
5. Accelerated Leaching Study (4 week composites sent monthly)
6. General Procedures to Reduce Variability and Avoid Errors
 - (a) Snow collections
 - measure volumes and prepare sample bottles as soon as possible after snow samples have melted
 - refrigerate sample bottles as soon as possible
 - at snow collection sites avoid knocking extra snow into collectors
 - don't lean over top of collectors
 - don't pick litter from snow-after snow has melted, pour off water and leave twigs etc. in bag
 - level all collectors
 - follow pertinent procedures listed under event procedures
 - (b) Litterfall
 - be sure to remove entire sample
 - clean mesh of foreign material before it is set up for next collection
 - mesh size may allow finer material through; may want to compare to other studies
 - use clean gloves when collecting and sorting each new sample type
 - use stainless steel tweezers when sorting
 - (c) Litter decomposition
 - remove foreign materials from bags on site
 - do not trample site
 - wear clean gloves for each sample type

- minimize handling to prevent sample loss through mesh.
- (d) Drying and Grinding
- oven dry samples at the correct temperature and for the appropriate length of time.
 - when grinding samples, clean the entire machine after each sample.
 - samples may be contaminated with nickel from the knife blades of grinder.
- (e) Lysimeters
- cover pits to prevent contamination and damage to bottle, tubing etc.
 - clean and check connections
 - keep collection bottle dark to prevent growth of algae
 - use pyrex collection bottles
- (f) Accelerated leaching columns
- ensure that drip rate is consistent
 - avoid spillage
 - ensure proper contact of collection bottle - need air gap to allow proper flow
 - avoid touching inside of bottles etc.
 - check that solutions are prepared according to specification
 - check pH's with meter
 - refrigerate samples as soon as possible.

VI. Site Maintenance

1. Roadway Maintenance

- plow snow
- grade in spring
- clean culverts
- ditch for good drainage
- keep roadsides and gate clear

2. Instrument Clearing

- shovel snow from platform trailer areas and pathways
- keep monitors free of snow
- clear pathways of brush
- level instruments
- lubricate and clean instruments
- cut grass once a year

3. Weir Maintenance

- winterize to reduce heat loss
- clean weir box of sediments once a year

4. O₃, NO_x and SO₂ Monitors

- standardize and check for zero and span
- change intake filters

5. Trailers

- check power, heating and air conditioner
- clean and repair.

VII. Data Management

Procedures to Reduce Variability and Avoid Errors

- (a) Maintain proper decimal places when transferring data from the field sheets to the computer.
- (b) Check that the computer programs are formatted to read each data set correctly.
- (c) Double check calculations.
- (d) Use standard rounding off procedures to obtain significant digits.
- (e) Check for outliers.
- (f) Check that all regions are treating missing data and flagged values in an acceptable and consistent manner.
- (g) Have back up copies of all diskettes.
- (h) Ensure proper storage of diskettes.

APPENDIX B

PUBLICATIONS AND REPORTS RELEVANT TO THE HAWKEYE LAKE BIOGEOCHEMICAL SITE STUDIES

I. REGULAR REPORTS ON HAWKEYE LAKE BIOGEOCHEMICAL SITE STUDIES

Annual Reports	1982-1983
APIOS Terrestrial Effects Programme	1983-1984 1984-1985
Northwestern Region:	
Quarterly Reports	April-June 1982
APIOS Terrestrial Effects Programme	July-Sept 1982 Oct-Dec 1982
Northwestern Region:	Jan-March 1983 April-June 1983 July-Sept 1983 Oct-Dec 1983 Jan-March 1984 April-June 1984 July-Sept 1984 Oct-Dec 1984 Jan-March 1985 April-June 1985 July-Sept 1985 Oct-Dec 1985

Quarterly Work Plans	July-Sept 1982
APIOS Terrestrial Effects Programme	Oct-Dec 1982
	Jan-March 1983
Northwestern Region:	April-June 1983
	July-Sept 1983
	Oct-Dec 1983
	Jan-March 1984
	April-June 1984
	July-Sept 1984
	Oct-Dec 1984
	Jan-March 1985

II. Miscellaneous Reports on Hawkeye Lake Biogeochemical Site Studies Produced by the APIOS Terrestrial Effects Programme, Northwestern Region and/or its Consultants

1983 - About Acid Rain Studies at Hawkeye Lake (Ministry Fact Sheet)

1984 - Hawkeye Lake Biogeochemical Study Site Preliminary Report

- Selection of Jack Pine Stands
- Snow pH Levels
- Seismic Study

1985 - Biomass Methods

- Accelerated Leaching Study
- Hydrological Monitoring Methods
- Soil Survey Methods
- Leaf and Twig Litter Decomposition Methods

1986 - Draft Status Report on Hawkeye Lake Forest Inventory and Biomass/Bioelement Studies

- Pukaskwa Soil and Vegetation Report
- Comparisons of Bulk Versus Proportional Pooling

III. Proposals for New Studies at Hawkeye Lake Biogeochemical Site Proposed by
the Consultants to the Programme

1982 - Forest Inventory

1983 - Soil Leaching
Hydrological Monitoring

1984 - Snow Sampling
Biomass
Trace Elements
Jack Pine Site
Moss - Humus Layer
Litter Decomposition
Soil Survey

1985 - Shrub Throughfall
Age-Increment Study and Shrub Inventory
Shrub Coverage Inventory
Integrated Approach to Data Collection, Management, Analysis and
Modelling of Acidic Precipitation in Forested Watersheds
Zero-tension Lysimeters
Seismic Survey

APPENDIX C

LIS LOCATION CODES

Note: The Northwestern Region of the APIOS programme has been allotted the location codes from 6001000 to 6009999 and 601800 to 6020000.

1. Location Codes for Studies Outside the Hawkeye Lake Watershed

Baseline vegetation 160 codes between 6005001 and 6005168

Baseline soil 6001183 - 6001214; 6001234 - 6001237

Pukaskwa soil 6001259 - 6001274

Birch seedling study 6001256 - 6001258
(soil samples)

D. Targen's Soil variability study 6001275

Accelerated Leaching:

Leachate	Column	Location Code
	A	6002501
	B	6005502
	C	6002503
	D	6005504
	E	6003505
	F	6002006
	G	6002507
	H	6002008
	* I	6004509
	* J	6003510
	K	6004511
	L	6003512
	M	6004513
	N	6005514
	O	6002015

*Columns I and J are black, other are white.

Solution

pH	2.0	6002000
	2.5	6002500
	3.5	6003500
	4.5	6004500
	5.5	6005500
distilled water QC check		6005000

Soil: 6001251 - 6001255

2. Location Codes for Biogeochemical Site - Hawkeye Lake Watershed

6001276 - 6001300 Soil Survey

6006001 Hydrology site #1 (standpipe at Lake)

6006002 Hydrology site #2

6006004 Hydrology site #4

6006005 Hydrology site #5

6006006 Hydrology site #6

6006007 Hydrology site #7

6006008 Hydrology site #9

6006010 Hydrology site #10

6006012 Hydrology site #12

6006013 Hydrology site #13

6006014 Hydrology site #14

6006017 Hydrology site #17

6006018 Hydrology site #18

6006020 Hydrology site #20

6006021 Hydrology site #21

6006023 Hydrology site #23

6006024 Hydrology site #24

6006030 Snowpack on ice of Hawkeye Lake

6006031 Ice on Hawkeye Lake

6006032 Hawkeye Lake water (winter)

The following location codes consist of two parts: the first 6 digits denote the site and the last 2 digits denote the sample type.

First 5 digits of a 7-digit code:

60180	Instrument platform
60181	Poplar site (Trembling aspen)
60182	Balsam site
60183	Old white birch site
60184	White pine site
60185	Stream site
60186	New white birch site
60187	Biomass sites along road
60188	Jack pine site
60189	Black spruce site
60190	See - Moss-humus layer study (G. Vanson)

Final 2 digits of location code refer to collection and sample types:

01	Combined throughfall
02	Combined stemflow
03	Combined shrub throughfall
04	Combined lysimeters LFH - A horizon
05	Combined lysimeters B Horizon
06	Combined lysimeters C Horizon
07	Litterfall foliage
08	Litterfall twigs
09	Litterfall other foliage and miscellaneous
	Note: Litterfall continued at 35
10	Snow sample
11	Aerochem
12	Sangamo
13	Low Vol

14 Stream sample
15 Poplar biomass tree #4
16 Poplar biomass tree #2
17 Poplar biomass tree #3
18 Black spruce biomass tree #2
19 Black spruce biomass tree #1
20 White birch biomass tree #4
21 Black spruce biomass tree #5
22 Poplar biomass tree #5
23 Balsam biomass tree #5
24 Birch biomass tree #3
25 Balsam biomass tree #4
26 Poplar biomass tree #1
27 Birch biomass tree #2
28 Balsam biomass tree #1
29 Balsam biomass tree #2
30 Birch biomass tree #1
31 Black spruce biomass tree #4
32 Balsam biomass tree #3
33 Birch biomass tree #5
34 Black spruce biomass tree #3
35 Litterfall (cont'd) miscellaneous
36 Litterfall (cont'd) all categories combined
37 Litterfall (cont'd) main foliage, other foliage
38 Litterfall (cont'd) main foliage, twigs
39 Litterfall (cont'd) main foliage, misc.
40 Litterfall (cont'd) main foliage, twigs, misc.
41 Litterfall (cont'd) main foliage, other, misc.
42 Litterfall (cont'd) main foliage, twigs, misc.
43 Litterfall (cont'd) other, twigs
44 Litterfall (cont'd) other
45 Litterfall (cont'd) other, twigs, misc.
46 Litterfall (cont'd) twigs, misc.
51 Litter decomposition - leaves

- 52 Litter decomposition - twigs
- 53 Zero tension lysimeter - LFH - A horizon
- 54 Zero tension lysimeter - B horizon

6018065 Clearing Snowpack Sample

Moss-Humus Layer Study (G. Vanson)

- 6019047 Moss Leachate
- 6019048 Humus Leachate
- 6019049 Throughfall
- 6019055 Soil Profile Studies Site 1-1 pH 3.0
- 6019056 Soil Profile Studies Site 1-1 pH 4.1
- 6019057 Soil Profile Studies Site 1-1 Distilled Water
- 6019058 Soil Profile Studies Site 1-1 Control
- 6019059 Soil Profile Studies Site 1-1 Centre E
- 6019060 Soil Profile Studies Site 1-1 Centre W

- 6019061 Moss Sample Site 1-1 pH 3.0
- 6019062 Moss Sample Site 1-1 pH 4.1
- 6019063 Moss Sample Site 1-1 Distilled Water
- 6019064 Moss Sample Site 1-1 Control
- 6019065 Moss Sample Site 1-1 Centre E
- 6019066 Moss Sample Site 1-1 Centre W

APPENDIX D

LIS TEST CODES

(Note: for Low Vol - units are all ug/filter)

ACDG	Acidity, Gran Endpoint (ug/L as H)
ACDT	Acidity, Total (mg/L as CaCO_3)
ALECA	Aluminum, Extracted in CaCl_2 (ug/g dry as Al)
ALEDI	Aluminum, Dithionate Extractable (% dry wt. as Al)
ALEOX	Aluminum, Oxalate Extractable (% dry wt. as Al)
ALEPY	Aluminum, Pyrophosphate Extractable (% dry wt as Al)
ALESC	Aluminum Exchangeable: Sodium Chloride Extracted (ug/g dry as Al)
ALEW	Aluminum Extract in Water (ug/g dry as Al)
ALPBT	Aluminum, Precipitation Bag 5% HNO_3
ALPDT	Aluminum in Precipitation (mg/L as Al)
ALUT	Aluminum, Unfiltered Total (ug/g dry as Al) (Also given as mg/L as Al - Stream data)
ASUT	Arsenic, Unfiltered Total (ug/g dry as As)
BBUT	Boron, Unfiltered Total (ug/g dry as B)
CAESC	Calcium, Exchangeable: Sodium Chloride extracted (ug/g dry as Ca)
CAUR	Calcium, Unfiltered Reactive (mg/L as Ca)
CAUT	Calcium, Unfiltered Total (ug/g dry as Ca)
CCO3UR	Total Carbonates, Unfiltered Reactive (no units)
CDPDT	Cadmium in Precipitation (mg/L as Cd)
CDUR	Cadmium, Unfiltered Reactive (ug/filter as Cd)
CDUT	Cadmium, Unfiltered Total (ug/g dry as Cd)
CEC	Cation Exchange Capacity (MEQ/100 g)
CLAY	Clay, particle Size (percent)
CLIDUR	Chloride, Unfiltered Reactive (mg/L as Cl)
CLUT	Chlorine, Unfiltered Total (% dry wt as Cl)

COD	Organic Carbon (will be renamed ORGA) (Note: computer prints it as Chemical Oxygen Demand, but this incorrect)
COND25	Conductivity (umho/cm at 25C)
COUT	Cobalt, Unfiltered total (ug/g dry as Co)
CRUT	Chromium, Unfiltered Total (ug/g dry as Cr)
CUPBT	Cu Precipitation Bag 5% HNO3 (mg/L as Cu)
CUPDT	Copper in precipitation (mg/L as Cu)
CUUR	Copper, Unfiltered Reactive (ug/filter as Cu)
CUUT	Copper, Unfiltered Total (ug/g dry as Cu)
FEEDI	Iron, Dithionate Extractable (% dry wt as Fe)
FEEOX	Iron, Oxalate Extractable (%)
FEEPY	Iron, Pyrophosphate Extractable (% dry wt as Fe)
FEPBT	Fe Precipitation Bag 5% HNO3 (mg/L as Fe)
FEPDT	Iron in Precipitation (mg/L as Fe)
FEUR	Iron, Unfiltered Reactive (ug/filter as Fe)
FEUT	Iron, Unfiltered Total (ug/g dry as Fe) (also given as mg/L as Fe - Stream Data)
FFUT	Fluorine, Unfiltered Total (ug/g dry as F)
HGUT	Mercury, Unfiltered Total (ug/g dry as Hg)
KKESC	Potassium, Exchangeable: Sodium Chloride Extracted (ug/g dry as K)
KKUR	Potassium, Unfiltered Reactive (mg/L as K)
KKUT	Potassium, Unfiltered Total (% dry wt as K)
MGESC	Magnesium, Exchangeable: Sodium Chloride Extracted (ug/g dry as Mg)
MGUR	Magnesium, Unfiltered Reactive (mg/L as Mg)
MGUT	Magnesium, Unfiltered Total (ug/g dry as Mg)
MNEDI	Manganese, Dithionate Extractable (% dry wt as Mn)
MNEOX	Manganese, Oxalate Extractable (%)
MNEPY	Manganese, Pyrophosphate Extractable (% dry wt as Mn)
MNPDT	Manganese in Precipitation (mg/L as Mn)

MNUT	Manganese, Unfiltered Total (ug/g dry as Mn) (also given as mg/L as Mn - Stream Data)
MOUT	Molybdenum, Unfiltered Total (ug/g dry as Mo)
NAUR	Sodium, Unfiltered Reactive (mg/L as Na)
NAUT	Sodium, Unfiltered Total (ug/g dry as Na)
NIPDT	Nickel in Precipitation (mg/L as Ni)
NIUR	Nickel, Unfiltered Reactive (ug/filter as Ni)
NIUT	Nickel, Unfiltered Total (ug/g dry as Ni)
NNHTR	Ammonium, Total: Frac. React. (mg/L as N) (also called Fil. Reactive)
NNHTUR	Ammonium, Total Unfiltered Reactive (mg/L as N)
NNO3UR	Nitrate, Unfiltered Reactive (mg/L as N)
NNRICF	Nitric Acid, Filt. Reactive (ug/filter as N)
NNTKUR	Nitrogen, Total Kjeldahl, Unfiltered Reactive (mg/g dry as N) (also given as mg/L as N - Sangamo)
ORGC	Organic Carbon
PBPBT	Pb Precipitation bag 5% HNO3 (mg/L as Pb)
PBUT	Lead, Unfiltered Reactive (ug/filter as Pb)
PBUT	Lead, Unfiltered Total (ug/g dry as Pb) (- Log (H+ (CONCN)))
PHECA	pH, Calcium Chloride Extractable
PHEW	pH, Water Extractable
PP04FR	Phosphate, Frac. React. (mg/L as P) (also called Fil. react)
PP04SB	Available Phosphorus, Sodium Bicarbonate Extract (ug/g dry as P)
PPUT	Phosphorus, Unfiltered total (mg/g dry as P) (also given as mg/L as P - Sangamo)
RSTLOI	Residual Total Loss on Ignition (MEQ/100 g)
SAND	Sand, Particle Size (percent)
SBUT	Antimony, Unfiltered Total (ug/g dry as Sb)
SEUT	Selenium, Unfiltered Total (ug/g dry as Se)
SILT	Silt, Particle Size (Percent)

SS04EW Sulphate, Extractable in Water (ug/g dry as S)
 (Note: test replaces SS04UR)
 SS02FR Sulphur Dioxide, Fil. Reactive (ug/filter as S02)
 SS04UR Sulphate, Unfiltered Reactive (ug/g dry as S04)
 (also given as mg/L as S04 - Stream Data)
 SSUT Sulphur, Unfiltered total (% dry wt. as S)
 TIP alkalinity Total Inflection Point alkalinity
 VOL Volume (mL)
 VOLDDA Precipitation Bag Leach Volume (mL)
 VVPDT Vanadium in Precipitation (mg/L as V)
 VVUR Vanadium, Unfiltered Reactive (ug/filter as V)
 VVUT Vanadium, Unfiltered total (ug/g dry as V)
 ZNPBT Zn Precipitation Bag 5% HNO3 (mg/L as Zn)
 ZNPDT Zinc in Precipitation (mg/L as Zn)
 ZNUR Zinc, Unfiltered Reactive (ug/filter as Zn)
 ZNUT Zinc, Unfiltered Total (ug/g dry as Zn)
 (also given as mg/L as Zn - Stream Data)



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MOE/APIOS/TER/ALLW

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SENES Consultants Ltd.
Terrestrial effects
programme

allw

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